Cost-Benefit Analysis and Regulatory Reform: An Assessment of the Science and the Art

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Discussion Paper 97-19

January 1997

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Abstract

The continuing efforts in the 104th Congress to legislate requirements for cost-benefit analysis (CBA) and the revised Office of Management and Budget guidelines for the conduct of such assessments during a regulatory rulemaking process highlight the need for a comprehensive examination of the role that CBA can play in agency decision-making. This paper summarizes the state of knowledge regarding CBA and offers suggestions for improvement in its use, especially in the context of environmental regulations.

Key Words: cost-benefit, cost-effectiveness, risk management, regulatory reform

JEL Classification Nos.: D6, L5

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Executive Summary

The continuing efforts in the 104th Congress to legislate requirements for cost-benefit analysis (CBA) and the revised Office of Management and Budget (OMB) guidelines for the conduct of such assessments during a regulatory rulemaking process highlight the need for a comprehensive examination of the role that CBA can play in agency decision-making. This paper summarizes the state of knowledge regarding CBA and offers suggestions for improvement in its use, especially in the context of environmental regulations. Its scope is not confined to assessments of cancer risks or other toxic-substance concerns; rather, it addresses the entire range of environmental policy issues.

CBA is a technique intended to improve the quality of public policy decisions, using as a metric a monetary measure of the aggregate change in individual well-being resulting from a policy decision. Individual welfare is assumed to depend on the satisfaction of individual preferences, and monetary measures of welfare change are derived by observing how much individuals are willing to pay, i.e., willing to give up in terms of other consumption opportunities. This approach can be applied to nonmarket "public goods" like environmental quality or environmental risk reduction as well as to market goods and services, although the measurement of nonmarket values is more challenging. Cost-effectiveness analysis (CEA) is a subset of CBA in which a policy outcome (e.g., a specified reduction in ambient pollution concentration) is taken as given and the analysis seeks to identify the least-cost means for achieving the goal (taking into account any ancillary benefits of alternative actions).

To its adherents, the advantages of CBA (and CEA) include transparency and the resulting potential for engendering accountability; the provision of a framework for consistent data collection and identification of gaps and uncertainty in knowledge; and, with the use of a money metric, the ability to aggregate dissimilar effects (such as those on health, visibility, and crops) into one measure of net benefits.

Criticisms of CBA hinge on questions about the assumption that individual well-being can be characterized in terms of preference satisfaction, the assumption that aggregate social well-being can be expressed as an aggregation (usually just a simple summation) of individual social welfare, and the empirical problems encountered in quantifying economic value and aggregating measures of individual welfare. We take the first as axiomatic, noting that because CEA is a subset of CBA, philosophical objections to the use of a preference-based approach to individual welfare measurement apply equally to both. As to the second, we agree that CBA

does not incorporate all factors that can and should influence judgments on the social worth of a policy and that individual preference satisfaction is not the only factor; nevertheless, we assert that CBA must be included as a key factor. The problems referred to in the third criticism are measurement problems--how choices based on preferences permit one to infer economic values in practice.

The state of the science of measuring such economic values is exceedingly active. Estimates of the willingness to pay for reductions in mortality and morbidity risks, for avoiding environmental damage to recreation opportunities, and for avoiding visibility degradation constitute the busiest and most-successful activities in the field of valuation. Issues of a higher order stalk the estimation of nonuse values, and a variety of mostly empirical concerns have left material damage poorly understood. Estimation of the costs of reducing environmental effects, generally thought to be relatively straightforward, is at least as challenging as estimation of the benefits, although there are easy-to-estimate, but perhaps poor, proxies for the loss of social well-being that such costs represent.

This paper offers a number of suggestions to regulatory agencies in conducting CBA, drawing on the "best practices" identified in new guidelines recently issued by the Office of Management and Budget (OMB). These include the use of clear and consistent baseline assumptions; the evaluation of an appropriately broad range of policy alternatives, including alternatives to new regulation; appropriate treatment of discounting future benefits and costs and accounting for the cost of risk-bearing; the use of probabilistic analyses and other methods to explore the robustness of conclusions; the identification of nonmonetizable or nonquantifiable aspects of a policy and the potential incidence of all effects; and the use of benefit and cost measures that are grounded in economic theory (measures of willingness to pay and opportunity cost).

We also argue that from an economic perspective, risk assessment is a subset of benefits analysis in that quantitative relationships between pollution exposure and some human or ecological response are needed to estimate the effects and therefore the marginal change in welfare that results from a policy. That the culture of risk assessment is not generally oriented toward this role implies that risk assessments do not always provide the necessary input to an economic benefits analysis. Suggested changes in risk-assessment practices include estimating population risks, not just individual risks; providing information on the entire distribution of risks, including central tendencies, rather than just upper-end risk measures based on conservative assumptions about the potential threat; providing as much information as is practicable about how risks vary with exposure, rather than just identifying "safe" or "acceptable" thresholds of exposure; and considering substitution risks as being as important as direct risk reductions. Economists and risk assessors together must also address how to give appropriate attention to both lay perceptions and expert assessments of risks.

The improvements in the methods for estimating the costs and benefits of regulatory activities discussed above are necessary but not sufficient for substantially improving

regulatory decisions. Several more overarching issues involving the role of CBA in public decision-making must also be debated and resolved. These include the following:

- Decision rules and CBA. Although decisions should not be based solely on a simple cost-benefit test, a CBA should be one of the important factors in the decision. This approach is consistent with Executive Order 12866. A rule with negative measured net benefits could still be promulgated with this approach if it could be shown that other factors (such as an improvement in the equity of the income distribution or an enhancement of environmental justice) justified the action. A discussion providing the justification would help to ensure accountability.

- Quantifiable benefits and costs. CBA needs to have standing as a part of all major regulatory *and legislative* decisions. In particular, CBA must have standing to implement the decision approach outlined above. Administrative reforms could accomplish much, but legislative changes will be needed to implement this suggestion where the use of CBA currently is precluded.

- Nonquantifiable elements and CBA. A value of information approach should be used. This involves estimating the net benefits for the quantifiable elements and asking how large the nonquantifiable elements would have to be to reverse the conclusion of the analysis or, as a broader measure, the regulatory decision. This provides information about nonquantifiables (beyond their enumeration and description) in a useful format for the decision-maker.

- Goals and standards--marrying efficiency and equity. CBA can be given appropriate standing and be introduced systematically into goal-setting without compromising other social concerns by first developing regulatory goals or aspirations, ideally expressed as ranges of acceptable risk and based on health or other criteria that reflect equity or fairness concerns. CBA, defined broadly, would then be used to justify where the standard would be set within this range or, to the extent that the range expressed aspirations versus more concrete requirements, how far toward the stated goal the regulation should go. An example of this approach can be seen in recent Congressional actions to reauthorize the Safe Drinking Water Act.

- Insuring credibility of analysis. Agencies need to be clear about their justification for proceeding with a regulatory action, especially when the regulation fails an implicit or explicit cost-benefit test. They should have the scientific and economic assessments underlying major rules peer-reviewed, and both the analysis and the peer review should be done early enough to influence the outcome, not as a rubber stamp on decisions made on other grounds. Peer review can be performed inside the agency (although the Environmental Protection Agency has recently dismantled this function), can be part of an interagency process, can be part of an expanded role for OMB, or can even be privatized. The combination of expanded peer review and timely completion of analysis would greatly support and enhance, respectively, the performance and perceived credibility of the existing Executive Branch regulatory review process managed by OMB.

Cost-Benefit Analysis and Regulatory Reform: An Assessment of the Science and the Art

Raymond J. Kopp, Alan J. Krupnick, and Michael Toman*

For the Commission on Risk Assessment and Risk Management

0. PURPOSE AND OBJECTIVES

The need for improvement in the content and process of regulation has been a consistent theme of policy leaders over the last 3 years. During this time, President Clinton has promulgated a major new executive order on regulatory planning and review, and the Office of Management and Budget (OMB) has issued revised guidelines for economic assessments of regulations. Of greater political salience, however, have been the efforts in the 104th Congress (building on similar but less sweeping efforts in the 103d Congress) to legislate requirements for cost-benefit analysis (CBA) and risk assessments. Whether one sees these efforts as attempts to make regulation and regulators more accountable or as attempts to subvert the achievement of important goals, the efforts have increased interest in the strengths and limitation of CBA as a tool for regulatory assessment.

This paper provides a summary of the state of knowledge regarding CBA of environmental regulations, an assessment of its capabilities, and some suggestions for improving both the state of knowledge and the state of the art in agency applications of CBA techniques. The first section of the paper provides an overview of this technique, the assumptions on which it rests, and critiques of those assumptions. Section 2 is a more detailed examination of the philosophic debates about CBA. Section 3 is a review of the state of knowledge regarding techniques for estimating the benefits and costs of regulations to protect the environment. Section 4 is a discussion of specific issues that arise in implementation of CBA. Section 5 considers some larger issues surrounding the application of CBA (such as the role of CBA as a decision rule and the treatment of nonquantifiables).

1. BACKGROUND ON COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS

1.A Introduction to Cost-Benefit Analysis

This paper addresses the use of cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA), a special case of CBA, in public decision-making. Although CBA and CEA are used in a wide range of public decision-making settings, we focus our attention here on their use in decisions concerning environment, health, and safety. Unlike the Commission's main report, we do not restrict our primary attention to regulations that affect toxic substances.

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CBA and CEA are economic techniques that produce information intended to improve the quality of public policies. In this context, *quality* refers to a measure of the social well-being that a policy conveys to society. Policies that reduce well-being are a priori inferior to those that improve well-being, and policies that improve well-being a great deal are superior to those which improve it only marginally. Conceptually, then, CBA could be used to rank policies on the basis of their improvements or reductions in well-being. For example, on the basis of such improvements, one could rank three air-quality policies that are related to urban ozone and that offer various ambient ozone standards to be attained, various reductions in illnesses related to ozone exposure, and various costs of attaining those standards.

CEA is a particular form of CBA. In the example of air quality above, one would use CEA if it is determined that the standard-setting portion of the air-policy decision has already been made (e.g., to tighten the current ambient ozone standard to 0.10 ppm) and the decision-maker must choose among options all of which attain the 0.10-ppm standard but through different approaches that give rise to different costs. CEA does *not* imply choosing the policy with the smallest dollar price tag (although many people believe that it does). Strictly speaking, CEA chooses the policy that achieves the specified goal with the smallest loss in social well-being. The smallest welfare loss might not be associated with the smallest dollar cost.

The remainder of this section introduces terms and concepts that will be used throughout the paper. It draws on the language of welfare economics, the subdiscipline of economics that gives CBA and CEA their intellectual foundation. Many of the terms that will be used, like *economic value*, have specific definitions in economics.

1.B Social Welfare

We have used *social well-being* as an indicator of social quality--in the abstract, the combination of all the things that members of a society see as contributing to the quality of their lives, individually and collectively--without enumerating what those factors might be. However, to develop empirical measures of well-being in CBA, we need a concrete definition of *well-being*. To avoid confusing the abstract notion of well-being with its operational counterpart, we will hereafter term the latter *social welfare*. Unlike the components of well-being which are left vague and open to interpretation, the components of social welfare included in CBA must be clearly delineated and therefore will give rise to disagreements about what is included and what is excluded.

Social welfare is meant to be a yardstick that permits us to look at our society in alternative states of the world and choose the state in which we are best off. Because the well being of a society is based on so many things, reducing it to a single measure might on its face seem ridiculous. Politicians, and the general public for that matter, routinely compare countries on the basis of gross domestic product (GDP) per capita and often evaluate our own economy and society on the basis of household disposable income and the distribution of that income. However, many of the important aspects of well-being are left out by such

simplifications. Nevertheless, such a simplification can contribute to understanding important public policy issues.

The concept of social welfare is meant to offer a single measure that captures as many as possible of the important features of well-being that might be affected by a policy. For example, if a range of policies under consideration affected only GDP per capita and we could state that, all other things being equal, higher GDP per capita led to greater well-being, then we could base our measure of social welfare simply on GDP per capita. In fact, economists have long recognized that GDP per capita is not a reliable measure of either individual or social well-being, because market values do not encompass all the important economic values (such as environmental protection) and because market values that do exist might suffer from distortions that mask underlying economic values (as in the exercise of market power by a monopoly). More generally, it is clear that many important aspects of well-being could be left out by a simple measure of welfare. However, a measure of social welfare need not capture all aspects of well-being to be useful for decision-making.

If one accepts for the sake of argument that a measure of social welfare is a reasonably good approximation by which to evaluate the well-being of a society, then CBA can be simply described as a study to determine what effect a proposed policy would have on the value of this social-welfare metric.[1] Other things being the same, policies that would increase welfare as indicated by the metric would be preferred to policies that would reduce welfare, and policies that would increase welfare more would be preferred to policies that would increase welfare less.

CEA analysis is a study of two or more policies with the same or very similar types of desired outcomes to determine which policy leads to the least net detriment in social welfare. CEA thus ranks the policies on the basis of the detrimental effect that the costs will have on social welfare. One way CEA can treat differences in ancillary benefits is as negative costs in the policy comparisons.

Constructing the measure of social welfare used in CBA can in principle be broken into two steps. In the first step, one attempts to develop measures of well-being for individual people in a society. In the second step, one aggregates the measures of individual welfare to form a measure of aggregate social welfare. The individual measures are subject to two critical concerns: the appropriateness of the single measure chosen as a valid measure of an individual's well-being and the problems that one faces when attempting to quantify the components of the measure. The appropriateness of the aggregate measure depends on both the appropriateness of the individual measures and their aggregation.

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[1] Formally, the measure of social welfare used in CBA is an index. That is, it is a mathematical aggregation of numerous components to form a single numeric value.

To find CBA or CEA useful and appropriate for public decision-making, one must find that the index of social welfare used in the CBA or CEA studies is a reasonably good metric by which to measure the well-being of a society. It is safe to say that much of the criticism of CBA starts and ends with a rejection of this view. These critiques are discussed in Section 2. CEA is a special case of CBA, so the concerns expressed above are as relevant to CEA as they are to CBA. Therefore, we focus our attention on CBA with the recognition that the same reasoning holds for CEA (unless explicitly noted otherwise).

1.C Individual Preferences

Individual measures of well-being are premised on a fundamental economic assumption: that the satisfaction of individual preferences gives rise to individual well-being. Economists take this assumption as a matter of faith, and it underlies most if not all of economic theory. Others reject the assumption outright. At its base, the assumption is that individuals know what is good for them (what will enhance their well-being), their preferences for actions and outcomes reflect this knowledge, and they act in a manner consistent with these preferences in a desire to increase their well-being. The validity of the "preference satisfaction" assumption has been debated since Bentham and will continue to be debated. There is nothing we can add to the debate but to note simply the crucial importance of the assumption to the intellectual foundation of CBA.[2]

If we accept the preference satisfaction assumption, we can look to people's actions as guides to their well-being. For example, if we see a person exchanging $3 for a six-pack of beer, we can state that the exchange made the person better off (increased the person's well-being) on the grounds that actions are motivated by a desire to satisfy preferences. But how much better off? The answer to that question brings us to the concept of *economic value*.

1.D Economic Value

To economists, the term *value* has a specific meaning that we hereafter refer to in this paper as *economic value*.[3] The most important, but often overlooked, features of economic value are that it is a theoretical construct and that monetary measures of it are inferred by analysts from the actions that people make in accordance with their preferences. Economic

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[2] If one wishes to delve into the debate regarding preference satisfaction one can begin with the exchange between Sagoff (1993) and Kopp (1993). More strictly philosophical discussions can be found in Williams (1985) and Scanlon (1991).

[3] The term value as used by economists causes a great deal of confusion. For example, if one asked you what are your "values" you probably would not respond by saying $2.00 for a Big Mac or $30 for a round of golf at a public course. Rather, when asked about your values, you might say things like honesty or hard work. Similarly, if one asked you what value do you place on the environment, you might say the need to preserve it for future generations, or you might mention your commitment to environmental stewardship and conservation. You would probably not say, $32 per day to view Bald Eagles along the California Coast.

value cannot be independent of an action, in particular, a type of action that requires a person to make a *choice* whereby something is given up and something gained.

For economists, the study of choice allows economic values to be defined and quantified.[4] Choice implies that a person is confronted with a selection of alternatives and that the consideration of the alternatives defines a tradeoff. The economic theory of individual behavior, based on the assumption of preference satisfaction, suggests that when a person is confronted by choices, the alternative that is chosen must be at least as desirable, from the perspective of that person, as the alternatives that were not chosen. The theory implies that the alternative chosen is at least as good or as valuable as the alternatives that were not chosen; the value of the alternative chosen is thus defined in terms of the alternatives foregone. For example, if a person chooses to relinquish three apples to gain a peach, an analyst can state that under the circumstances of the choice (perhaps known in their entirety only to the person), the economic value of the peach to the person is at least three apples. If the choice were to give up $1 for the peach and the person chose the peach, the analyst would conclude that the value of the peach to that person was at least $1.[5]

Now that we have defined economic value, we can return to the problems of measuring changes in individual well-being. Suppose that a policy is being considered that would lower the price of peaches by 25% and have no other consequences. From the perspective of the person who is willing to pay at least a dollar for a peach, the policy enables him or her to pay only $0.75. The difference between the amount given up and the economic value of the peach is a monetary measure of the increase of the person's well-being--in this case $0.25.[6]

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[4] One could say that the analyst "constructs" the economic value rather than estimating them. The verb constructs underscores the notion that economic value does not exist in a free standing fashion amenable to empirical measurement. Rather, economic value can only be measured with reference to a choice, and the characteristics of that choice largely determine the measured value.

[5] To monetize economic value, the foregone alternative (defined by an individual's choice within a specified trade-off) must be expressed in dollars. Unfortunately, this monetization has sometimes created misconceptions. For example, it has been suggested that economic values are confined to prices observed in markets. These misconceptions arise because many people commonly think of the monetary measure of economic value as a *price*; if a widget sells for $6 in a market, then $6 must be its value. This view is misleading, however. When a person buys a widget the analyst only learns that it is worth <u>at least</u> $6 to the buyer. He or she might be willing to pay much more than $6 if necessary to get the widget. Markets do offer opportunities for people to make choices, but it is these choices and the circumstances relevant to them that permit construction of the underlying economic values, not the existence of markets and market prices *per se*.

[6] Policies rarely affect only one good or one price. Most often they affect many goods and many prices. But if we knew the economic value of all the goods affected by the policy and the effects on those goods of the policy, we could aggregate the monetary measures of well-being gains or losses across all the affected goods to capture the full impact of the policy on individual well-being.

Later in this paper, we will discuss in detail the problems faced by an analyst in attempting to place economic values on "commodities" that are not exchanged in markets (e.g., reductions in the risk of exposures to health-impairing air pollutants). What we wish to note here is that quantifying the economic value of "commodities" that are affected by a policy and then determining how the policy affects the tradeoff that people make regarding those "commodities" permits the economist to quantify the change in a person's well-being brought about by the policy.

1.E Aggregation from the Individual to Society

A crucial step in CBA is the aggregation of measures of individual welfare to form a measure of social welfare. In the most common applications of CBA, the aggregation of individual welfare treats all individuals anonymously. That is, no person's welfare is weighted more heavily in the aggregation than another's. The changes in all individuals' welfare are simply totaled. If a policy increases the welfare of rich people and decreases the welfare of poor people, but the rich people's gain outweighs the poor people's loss, the anonymous-aggregation rule would label this change an improvement in aggregate social welfare. That example forms the basis for the criticism that CBA neglects important distributional considerations.

However, nothing in the theory of welfare economics dictates an anonymous-aggregation rule. In theory, different segments of society or even individuals can be given different weights in the aggregation. The reasons one rarely sees CBA studies that use such preferential weighting will be discussed in Section 2.

1.F Summary

We have attempted in this section to provide a brief overview of the economic foundations of CBA and CEA that can serve as a basis for the more detailed discussion to follow. We have stated that CBA is a technique intended to improve the quality of public-policy decisions, whose quality is defined according to the change in social well-being that they bring about. CBA forces one to use a measure of social well-being, which we refer to as social welfare. The measure of social welfare in CBA and how it is affected by a policy depend on how the welfare of individuals is affected by the policy and how individuals' welfare levels are aggregated. Finally, individual welfare is *assumed* to depend on the satisfaction of preferences and on the theoretical construct of economic value derived from the axioms of preference satisfaction.

2. CONCEPTUAL STRENGTHS AND LIMITATIONS OF COST-BENEFIT ANALYSIS

2.A Introduction

The purpose of this section is to review the debate over strengths and limitations of CBA for public decision-making. We will pass over the strengths of CBA quickly and devote most of the discussion to the limitations; we have chosen this emphasis in the belief that the strengths are widely known, but that the many limitations (perceived and real) are the subject of considerable debate.

We will see that a discussion of CBA limitations reaches far beyond the boundaries of welfare economics and touches complex ethical issues and the political underpinnings of a democracy. We hope to point out that some of the better-known criticisms of CBA analysis are reflections of differences of opinion regarding the assignment of fundamental rights.

2.B Strengths

2.B.1 Transparency

The results of a well-executed CBA can be clearly linked to the assumptions, theory, methods, and procedures used in it. This transparency can add to the accountability of public decisions by indicating where the decisions are at variance with the analysis.

2.B.2 Ignorance Revelation

CBA requires information regarding the effects that a policy can have on social welfare and provides the analyst with a template for collecting and organizing that information. The template character of CBA permits the decision-maker to determine the adequacy of the information collected and see important information is missing. This knowledge provides the decision-maker with valuable insight into the level of ignorance regarding important attributes of the policy.

2.B.3 Comparability

As noted in Section 1, CBA attempts to capture in a single index all the features of a policy decision that affect the well-being of society. The single-metric approach permits the comparison of policies that affect different attributes of well-being differently, that is, it permits the decision-maker to compare "apples" and "oranges" on the basis of a single attribute (the index of social welfare) common to both.

2.C Limitations

Many of the critiques of CBA encountered in everyday policy debates are echoes of the more conceptual issues that we address here. They include the following:

(i) The environment is a public good that is not exchanged in markets and therefore defies economic valuation. Thus, the use of CBA to evaluate environmental policies is inappropriate.

(ii) Environmental protection is often desirable for reasons that cannot be quantified -- social, spiritual, and psychological values that defy monetization.

(iii) CBA does not take the "rights" of future generations into account.

Criticisms of CBA focus on several overlapping points: the notion that preference satisfaction gives rise to individual well-being, the elements of the individual social-welfare

index, the notion that economic value is a measure of preference satisfaction, the empirical and philosophic problems encountered in quantifying economic value, the presumption that the well-being of society can be defined as some aggregation of the well-being of individual members of that society, and the methods by which the aggregation is performed. In the following section, we discuss each of those criticisms more fully. As indicated below, the response of CBA analysts to the criticisms is that CBA is largely an attempt to measure preferences formally. Legitimate questions can be raised about the practice of such measurement or the method of aggregation to describe social welfare. In contrast, we argue that the basic criticisms of the preference satisfaction concept are less persuasive.

2.C.1 Trumping Preference Satisfaction

We noted in Section 1 that preference satisfaction forms the philosophic foundation for CBA. We can greatly simplify the discussion of the limitations of CBA by prefacing our remarks with a brief discussion of instances in which society consciously chooses to make satisfaction of individual preferences subservient to higher-order social determinations. For example, it may be one's preference to drive while intoxicated, but society has determined (in a political process) that such behavior will not be permitted. The point is that society can choose to make preference satisfaction subservient to particular and explicit social determinations without undermining the intellectual integrity of CBA.[7] However, there might be other circumstances in which CBA of social determinations is useful in helping to decide whether the social strictures need to change. For example, blanket prohibitions on exposure to potentially hazardous substances might deliver relatively little benefit compared with their costs, particularly as the technologies for detecting very low levels of contamination improve.

2.C.2 Equity Considerations

It is often argued that CBA takes the existing distribution of income as given and does not consider the equity implications of the policies that it seeks to evaluate. This criticism points to the anonymous manner in which the welfare changes of individuals are aggregated to obtain estimates of the change in social welfare.

The criticism is valid as far as it goes. Anonymous weighting of individual welfare does not take equity into account. However, that need not be the case (Burtraw and Kopp, 1994). Because one can weight in any number of ways, the problem is that someone must state explicitly what the weights should be. Inasmuch as there is no established "right" to equity in the distribution of individual well-being, where would a policy-maker get the needed weights? She might decide to use her own weights, but the transparency of the CBA method would reveal them immediately, and those who disagreed could easily counter with their own weights. No unique set of equity weights have been sanctified through some political process, and anonymous aggregation has become the default in CBA. It has no claim to moral superiority

[7] Laws that bar discrimination are other obvious examples of instances where the preferences of some have been over-ridden by the political decisions of society as a whole.

or scorn. Even with this approach, however, more disaggregated CBA can provide important information about the incidence of effects.

2.C.3 Preference Satisfaction

CBA is meant to convey some normative information to decision-makers, namely, whether a policy could make the society better off than the status quo. The normative character of CBA is derived from the assumption that the satisfaction of individual preferences gives rise to individual well-being and that social well-being is a function of individual well-being. The preference satisfaction assumption is crucial to the normative properties of CBA, but one can do little to establish the validity of the assumption. Generally, either one finds it a reasonable assumption or one does not. We present two opposing views below.

Mark Sagoff, professor of philosophy and director of the Institute for Philosophy and Public Policy at the University of Maryland has provided a critique of environmental economics (Sagoff, 1993). Like most such critiques, his quickly focused on welfare economics in general and CBA in particular. In his critique of CBA, Sagoff attacked the preference satisfaction assumption. He wrote in part,

> My third argument against using the theory of welfare economics as a basis for allocating resources is that, even if preferences did exist as a foundation for "rational" choice, economists offer no plausible reason why environmental policy should seek to satisfy them.[8] Economists use the term "social welfare" as a proxy for the "satisfaction of preferences" and then trivially and speciously argue that the "satisfaction of preferences" produces social welfare. However, empirical evidence confirms what common wisdom suggests: not the satisfaction but the content and quality of desires correlates with what people mean by welfare or well-being.

To understand Sagoff's critique better, one can turn to Harvard philosopher Thomas M. Scanlon's philosophic critique of preference satisfaction (Scanlon, 1991). His critique provides a rare clarity of insight into the differences between economists and philosophers regarding the fundamental concept of individual well-being and what it is that makes a person better or worse off.

Following Scanlon, most economists would agree that when one speaks about individual well-being, one is necessarily making a value judgment. Scanlon suggests that this aspect of a well-being definition can be mitigated to a degree by "constructing a more concrete conception of welfare in terms of goods and conditions that are recognized as important to a good life even by people with divergent values." The idea is that one seeks to formulate a list of things giving rise to well-being "based on a shared conception of the important goods and

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[8] Sagoff's first argument has to do with economists' "market failure" rationale for government regulation, while the second questions whether individual's have "preferences" at all.

bads in life."[9] However, the issue that concerns us here is not the elements of the list, but how the elements are aggregated to define a measure of well-being that may be used to compare alternative social states.

Scanlon's answer to the problem of aggregating the elements of a list is to use an index. According to Scanlon, such an index must pass a test of adequacy and practicality. An index would be inadequate if it contained only a subset of elements that were deemed important to a "good life," for example, if it contained only wealth. So far, economists have no quarrel with Scanlon and are willing to define a set of elements (attributes) that give rise to well-being.[10] Economists would even find agreement with the second of Scanlon's index tests--practicality. Scanlon states, "The question of practicality takes account of the fact an index of well-being is something that will be used by individuals, including legislators and other officials, in assessing institutional contributions to welfare."

But we now come to the root of the disagreement. An index serves to aggregate elements of a list into a single value. In the simplest case, which will suffice here, aggregation to a measure of individual satisfaction is accomplished by weighting the elements and summing. But where do the weights come from? In welfare economics, the weights are derived from the economic values obtained from the observed choices of individuals, which economists attribute to underlying preferences.[11]

In contrast, Scanlon suggests that

> Satisfaction of people's "manifest" preferences is not an adequate index of well-being because there are conceivable circumstances in which these preferences might be satisfied even though the individuals' true interests were far from being served. The approach I am now describing avoids this problem, because it specifies an index of well-being not in terms of preference satisfaction but rather in terms of the availability of goods and conditions deemed important for a good life.

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[9] There are of course a large number of such lists. Scanlon discusses just one such list defined by Rawls (1971) as Primary Social Goods in his *A Theory of Justice*.

[10] This list obviously includes material goods and services as well as such intangibles as: friendship, love, self-esteem, religious and ethical views, etc. As it turns out, this list looks very much like the list of items one might find in a generalized microeconomic utility function. Moreover, economists, like philosophers, wish to find ways so that social states may be compared and would agree that an arbitrarily short list could very well be deemed "inadequate."

[11] The welfare economist Harsanyi states the economic view most directly, "The principle that, in deciding what is good and what is bad for a given individual, the ultimate criterion can only be his own wants and his own preferences" (Harsanyi, 1955). The "Principle of Autonomy" that Harsanyi articulates does not depend on the reasons one has for particular preferences. What matters for Harsanyi is that individuals apply the weights and the weights are permitted to be specific to each individual.

By rejecting preference satisfaction in favor of some "goods and conditions deemed important for a good life," Scanlon seems to suggest that people cannot be relied on to seek their own interests and that someone else must deem certain goods and conditions important for a good life. Who will make this determination and assign the relative weights? Sagoff indicates that these decisions should reflect considerations of personal freedom and a well-functioning democratic political process. Although economists would also support these things, they would see freedom as but one of a number of social attributes valued by individuals and the political process as another institution in which individuals singly and collectively pursue their interests.

Accepting the proposition that economic value is linked to the intensity of individual preferences and that choices based on preferences permit one to infer economic values does not imply that it is simple to infer these values. The problem of measuring values is most severe for tangible and intangible items that are not traded on organized markets, where one can observe the tradeoffs faced by individual and the choices they make, as discussed further below.

2.C.4 Elements of the Individual Social-Welfare Index

Two criticisms of the individual welfare indexes used in CBA bear on the elements that make up the index. The first has independent standing even if one accepts preference satisfaction. It argues that many preference-based factors can be influenced by a policy and that CBA includes only a subset of them as elements of the individual welfare index. That is a valid concern. For reasons of time, budget, tractability, and available information, some preference-based factors that might be affected by a policy might be left out of the index. To the extent that that happens and to the extent that the excluded factors are heavily affected by the policy and have high economic value (a large weight in the index), the results of the CBA will be affected in an unknown direction. How one can deal with this possibility is discussed below when we address implementation issues.

Like the first criticism, the second is logically valid even if one accepts preference satisfaction. It acknowledges that preferences are linked to individual well-being but claims that there is more to well-being than preferences. Naturally, if one defines preferences in such a narrow way as to exclude important attributes that affect well-being, this argument has some force. For example, if one were to limit preferences in the manner of simple models of "egoism,"[12] important aspects of well-being could well be left out. Another example of such a limitation in CBA is the exclusion of what economists call "nonuse" values implied in S. 343 (the Comprehensive Regulatory Reform Act of 1995).[13] However, it can equally be argued that these limitations are entirely arbitrary and the concept of preferences is rich enough to encompass all facets of life that give rise to well-being. Thus, the importance of this argument

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[12] Models of "egoism" generally restrict preference to those things that benefit the individual directly. Thus a "preference" for self-sacrifice in the attainment of some worthy goal, for example, would be excluded.

[13] See the report of the Senate Judiciary Committee on S.343, May 25, 1995, page 59.

seems to rest on how one chooses to define preferences and on whether one can identify factors other than preferences that affect well-being.

One such class of factors often mentioned is categorized as "ethical" considerations, including fairness to future generations or the integrity of conduct within the current generation in maintaining "critical" environmental resources. Some philosophers, such as Bryan Norton (1994), maintain this view. Others strongly dispute that ethical considerations are *not* a reflection of preferences, given a broad enough conception of preferences, and that the dispute is one of data and measurement rather than basic concept (Kopp, 1992).

2.C.5 Economic Value Is Not a Measure of Preference Satisfaction

The criticism here is relatively straightforward--that the economic value of some thing is not related to the well-being that a person enjoys as a result of that thing. For example, this argument implies that if one is willing to pay $3.00 for a bottle of imported beer and only $1.50 for a bottle of domestic beer, it is not possible to say that the person's well-being is greater if he or she is given an imported beer than it would be if he or she given a domestic beer.

For this argument to hold, it seems that one must assume that actions (choices) are not motivated by preferences or that people cannot make choices that reflect their preferences. We have already addressed this argument in Section 2.C.3 above.

2.C.6 The Economic Value of Some Things Cannot Be Measured

It is argued by some that there are things that humans cannot put a price tag on.[14] Aspects of the environment often fall into this category. That might well be true, but it does not imply that individuals cannot determine how important aspects of the environment are to them. As noted in Section 1 above, economic values are inferred from the choices made by individuals. It would be wrong to think of economic values as dollar-denominated numbers in one's brain to be downloaded when a person is asked the worth of a beautiful ocean sunset; rather, such a value might be inferred from the things that one gives up to see the sunset (e.g., the cost of travel to the ocean).[15] To economists, the importance of things (tangible or intangible) is revealed by what a person will give up to obtain them. The lower bound on the value of the item obtained is equated to what was given up. If the thing given up was money, the value can be expressed in monetary units; otherwise, it is expressed in the natural units of the thing given up.

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[14] A corollary to this statement is that there are some things that should not have a price tag placed on them.

[15] Analyses of the economic value of recreational experiences have used this approach, quantifying the monetary value of those things given up to recreate, to calculate a lower bound on the value of recreation experiences.

2.C.7 The Well-Being of Society Is Not Necessarily an Aggregation of Individual Well-Being

In the 18th century, economists seeking to avoid issues of interpersonal comparisons of well-being put forth the principle of Pareto optimality as a rule to be used when one seeks to decide among alternative public policies. A policy alternative is a Pareto improvement if at least one person's utility can be raised without lowering any other person's utility. That a Pareto improvement would be an improvement in the well-being of society seems relatively uncontroversial (other than for those who, as discussed above, reject the entire concept of utility as an indication of well-being). Unfortunately, few policies would pass the Pareto test -- more often, there are both winners and losers.

As a consequence, a weaker *compensation* test was proposed. The so-called Kaldor-Hicks notion of compensation implies that a policy is preferred to the status quo if all those who benefit from the policy could *in principle* compensate those who suffer and still remain better off. In the context of the compensation principle, the benefits of a policy are equal to the increased utility enjoyed by the beneficiaries, and the costs of the policy are equal to the compensation of the sufferers (see Kaldor, 1939 and Hicks, 1939). Alternatively, the benefits of a policy are equal to the maximal amount of money that people would be willing to pay to live in a world with the policy in force rather than not; conversely, the cost is equal to the minimal amount of money that people would require to live in a world in which they bore the costs of the policy.[16]

The compensation principle also suggests a way of representing the effects on social welfare of a policy in terms of the aggregate of changes in individual monetized effects. More precisely, the benefits of a policy could be said to exceed the costs if the aggregate of all beneficiaries' willingness to pay (WTP) for the program exceeds the aggregate of all sufferers' willingness to accept (WTA) compensation to live with the program. The major advantage of this approach from the perspective of CBA is that information on the monetary values of benefits or costs to various individuals can be simply aggregated to evaluate the social benefits and costs.

A number of objections to that approach are found in the literature. Over 40 years ago, the economist Kenneth Arrow proved an "impossibility theorem" stating that no simple representation of total social welfare--additive or otherwise -- simultaneously satisfied a number of intuitively desirable properties (Arrow, 1951). Although the truth of the theorem is not in dispute, it does not point to any alternatives for practical application of economic analysis in public-policy venues.

Aside from this theoretical objection from within economics, there are philosophic objections to both the compensation approach in particular and any welfare-aggregation measure in general. A common concern is that this fundamentally utilitarian approach leads to ethical quandaries, e.g., when a few people can benefit a lot by making the lives of others

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[16] In reality, beneficiaries and sufferers may be one and the same.

(either now or in the future) miserable. In effect, the problem here is one in which compensation cannot be or is not paid.

An alternative perspective is one based on some concept of justice, such as the Kantian imperative to treat others fairly or Locke's view that people have the right to be secure against losses imposed by the actions of others. In the environmental-policy arena, these perspectives are manifest in concerns for resource stewardship across generations and for fairness in access to current benefits (environmental justice). Unfortunately, no definition of what constitutes justice in these contexts is widely accepted. With the exception of Rawls's (1971) justice criterion, that the utility of the least well-off be maximized, it is not easy even to translate the criteria into measurable quantitative terms; this is not a disadvantage to their advocates, but it makes them obviously incompatible with CBA.

A more practical concern with aggregate net benefits measures is the equal weighting placed on all individuals. As noted before, however, such a weighting is not an inherent requirement of CBA; instead, it is a default assumption that reflects a lack of consensus about alternative weights to reflect distributional concerns.

3. MEASURING BENEFITS AND COSTS

A major part of the critique of CBA centers on measurement issues. This section provides an assessment of the state of the art of measuring benefits and costs of environmental improvements.

3.A Benefits

Table 3A-1 summarizes the major benefit categories related to the environment: health and related benefits to individuals, production, economic assets, and environmental assets. The health category can be divided into reductions in the risk of death and reductions in morbidity, and morbidity further divided into acute effects (whether in people with chronic illnesses or other people, i.e., "normals") and incidence of chronic disease. For valuation purposes, the acute effects are usually modeled as though they are certain to be avoided, whereas the chronic effects are usually treated probabilistically, i.e., as a reduction in the risk of developing a chronic disease. Another benefit to individuals might include reductions in anxiety about getting sick. Finally, depending on the comprehensiveness of the approach to estimating benefits, the reduction in avoidance activities, such as staying indoors instead of playing tennis on a high-pollution day, may be counted as an additional benefit. The last two categories are routinely ignored in risk assessments, which focus on illness, not the behavioral, and ultimately the valuation, consequences of changes in health risks.

Table 3A-1. Benefit Categories and Estimation Approaches

BENEFIT CATEGORY	ESTIMATION APPROACH[a]
To Individuals	Property Value (hedonic price)[b]
Health	
Mortality	Wage Compensation, Stated Preference Averting Behavior, Human Capital (foregone earnings)
Morbidity (acute, chronic)	Stated Preference, Cost of Illness (medical, earnings, pain and suffering, avoidance), Averting Behavior
To Production/consumption	
Crops/Forests/Fisheries	Consumer plus producer surplus
Water-using industry	Same
Municipal Water Supply Authorities	Opportunity Cost (alternative aquifer) Service Replacement (Municipal treatment, bottled water)
To Economic Assets	
Materials (corrosion, soiling)	Replacement Cost, Service Values, household production function
Property Values	Hedonic Price Models
To Environmental Assets	
Use	
Recreation	Unit Day, Stated Preference, Property Value, Travel Cost, Random Utility, Hedonic Travel Cost Service Replacement, Stated Preference, Property Value
Other (visibility)	
Passive Use (Nonuse)	Stated Preference Models

[a] See text for explanation of some of these estimation approaches. See Freeman (1993) for a detailed explanation of all approaches.

[b] For instance, increases in individual incomes from the economic rejuvenation of a remediated area. Care must be taken not to double-count benefits in this subcategory with benefits in the "production" category.

The major production activities (i.e., activities carried out in markets) likely to benefit from environmental improvements include agriculture, commercial fishing, and commercial forestry. Benefits might involve increases in yields or quality (including appearance). Manufacturing sectors that use freshwater in processing could also benefit from reduction in contaminants in their water supplies, as would municipal drinking-water suppliers.

Economic assets--such as building materials, property, and clothing (arguably classified as either an asset or a consumption good)--can benefit from reduced pollution by reducing material replacement rates, increased values of property thought to be at risk because of hazardous wastes, and reduced cleaning costs, respectively.

The last benefit category is environmental assets, a catch-all category that includes features of the natural environment whose degradation people would be willing to pay to avoid. Such assets include recreation areas, endangered species and their habitats, visual range, open space, and wetlands. It is recognized that people might value improvements in these assets because they use the services that such assets provide and because "they are there." Economists call the first kind of value "use value," and the second kind "passive-use value" or "nonuse value."

3.A.1 State of the Science

Table 3A-1 also lists approaches to estimating benefits. The techniques fall into two general categories: stated preferences and revealed preferences. The former involve asking people questions in surveys to elicit either directly or indirectly estimates of willingness to pay (WTP) for the improvement in question. The latter involve examining behavior, either in the marketplace or elsewhere, to discern WTP. Examples of the former approaches are contingent-valuation methods (CVMs), which are structured surveys meant to elicit preferences of subjects in monetary terms when they are confronted with a choice, and conjoint analysis, an approach used extensively in marketing to elicit preferences for particular combinations of product attributes. When such analyses involve the attribute of a price, the value of other attributes can be estimated.

There are a wide variety of revealed-preference approaches. The most developed probably are the hedonic-labor-market approach (see below), the property-value approach, and the travel-cost approach (TCM) to valuing recreation. The TCM approach has many variations, but basically it involves using the cost of travel to a recreation site as a measure of its "price" and then using the price information with information on the demanded quantity of recreation (perhaps of various qualities) to estimate a demand for the recreation activity or for improvements in its quality.

There are two dimensions for considering the state of the science. The first is the credibility of original studies. Moreover, because such studies are usually site-specific and coverage of all possible sites and situations is impossible, it is nearly always necessary to

transfer the results of the original study to the location or setting of interest. Thus, the second dimension is the reliability of benefit transfer.

One of the four categories, benefits to economic production, best lends itself to direct benefit estimation, inasmuch as standard market-based valuation techniques can be used in the estimation. If pollution reduction raises crop yields, for instance, this is modeled as an outward shift in the supply of the crop, meaning that more of this crop can be produced at any given market price. Given the demand for the crop and the assumption that the pollution change affects a substantial portion of the crop, the shift results in a lower price for the crop. As a result, consumers benefit. Producers also benefit because the inputs that they use appear more productive. Once the analyst can estimate the shift in supply (from concentration-response functions supplied by, in this case, plant scientists), these effects are easy enough to estimate from data collected on the market price and on quantities produced and sold and from published analyses of the responsiveness of supply and demand to price (price elasticities). Because this information for fisheries, crops, and forests is, at least for major products, generally available by region, benefit transfers are unnecessary.

The situation is quite different with respect to economic assets, such as building materials. Benefits cannot reliably be estimated in original studies, let alone in a benefit transfer. Material inventories are still lacking and no major modeling efforts for valuing the complex behavioral linkages necessary for a defensible material-benefit estimate have been undertaken in this country in many years.[17]

The health-benefits literature is reasonably well developed, and recent studies of the social cost of electricity have given these studies a very close review and consensus endorsement--although limitations remain (see below). This category is probably the easiest for making credible benefit transfers across locations, given comparable economic circumstances (comparison across affected populations with very different income levels or other socioeconomic circumstance is, in contrast, more difficult). Once atmospheric or other natural processes are taken into account (say, in the estimation of the effect of emission reductions on ambient air quality), one can presume to a first approximation that the health effects and the values that people place on avoiding them are reasonably similar across locations.

Some benefit transfers use unit values and unaided judgment to combine the different values obtained from the literature. Some use meta-analysis. Few use valuation functions, such as the kind arising from regression analysis explaining variation in WTP responses to a CVM survey. And the methods for establishment of error bounds and central estimates are ad hoc and heterogeneous across benefit-transfer studies.

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[17] The European Community study on the social costs of electricity (EC, 1995) provides a good example of how such inventories could be developed.

The credibility and ease of transfer of studies that value environmental assets vary greatly by subcategory. Taking each of the main subcategories in turn, the recreation-valuation literature is by far the most technically sophisticated. However, the recreation literature is of somewhat limited usefulness in estimating benefits of environmental improvements because most of it focuses on changes in the availability of resources, not on changes in their quality. Only a handful of studies incorporate explanatory variables related to pollution, such as water turbidity, nutrient concentrations, and the like. Most of the literature values catch rate changes, a starting point that, to be useful, requires that links be forged from the pollution concentrations to the effect on game fish or animal populations--a challenging undertaking to say the least.

Furthermore, benefit transfer of recreation values or demand functions is difficult. Accounting for regional factors (such as the range and quality of substitute sites and site-specific factors such as congestion is likely to be difficult. And there are no acceptable procedures for determining the "spatial extent of the market." That is, there is still lively debate on methods for determining the size of the population that would be or is affected by a change in recreation quality or quantity.

Because benefit transfers have generally followed the procedure of applying unit-day values to estimates of participation days, these values exist in great profusion for all types of uses and environments (Walsh, Johnson, and McKean, 1990), but application to specific sites is problematic--more so than the application of unit values to health because of the presumption that WTP to avoid health effects is less influenced by region and site variables than is WTP for recreation.

Considering the credibility of visibility-valuation studies, substantial debate surrounds protocols for eliciting values in contingent-valuation studies; for example, the size of photographs shown to respondents appears to influence WTP. There are also concerns over joint valuation of visibility and health by respondents (i.e., they use visibility as a proxy for health effects). Research efforts have concentrated too much on National Parks in the Southwest and not enough on valuing visibility effects at more mundane locations, both rural and urban.

Benefit transfer for valuing visibility also presents formidable challenges because of the sensitivity of values to region, site, and personal characteristics. The characterization of the policy and study site is particularly difficult for visibility benefit transfers. Visual range can be characterized in a relatively straightforward way, but the vista being affected is particularly difficult to characterize, beyond "urban," "rural," and "recreational area," which are unlikely to be sufficient. In addition, the extent of the market problem is even more difficult than that for recreation because "use" as a function of distance to the site can be observed for recreation, but not for some visibility problems (e.g., urban visibility).

Nevertheless, the literature on visibility benefits is fairly conducive to benefit transfer. There are studies of visibility values in multiple cities (Tolley et al., 1986b), which permit

examination of city-specific factors that affect values and derivation of functional relationships to predict WTP, given the baseline visual range and the size of the change (NAPAP, 1990). There are also a number of examples of benefit transfers involving visibility (Chestnut and Rowe, 1988). NAPAP (1990) presents a visibility-valuation function designed for benefit transfer. This function relates value per household to the log of the ratio of the change in visibility to baseline visibility. The WTP increases with the change in visibility at a decreasing rate and is lower for a given change from a higher baseline visual range. An analysis by Electric Power Research Institute and Decision Focus Inc. (1991), which examined benefits of improved visibility in the eastern United States from reductions in SO_2 emissions, is a particularly good example of a benefit transfer in which all the steps of the damage-function approach were linked together (i.e., emissions to concentrations, concentrations to optics, optics to perceptions, and perceptions to value).

The accumulated literature on nonuse values of environmental assets is growing but is still relatively small. Many of these studies concern nonmarginal changes in unique environments (e.g., species extinction and loss of an ecosystem), but the effects of environmental or other policies generally are marginal. Therefore, it is difficult to perform transfer involving nonuse values without undertaking an effort to obtain additional benefits information. However, as noted above, an example of a well-done nonuse-value benefits transfer is the Decision Focus Inc. (1990) Grand Canyon study.

3.A.2 Detail on Benefit-Estimation Approaches

Because the Commission is interested primarily in risk assessment and risk management as applied to health and ecosystems, we will confine our review of methods to these end points.

3.A.2.a Health Valuation

The estimation of health benefits of changes in pollution requires an understanding and careful integration of health science with economics. This integration involves matching as closely as possible the starting point of the valuation analysis to the end point provided by health science -- a health response (such as a symptom-day or an increase in mortality risk) or a health consequence (such as a hospitalization or a bed-disability day) to a specific population (e.g., asthmatics).

Estimation of health benefits has proceeded for many years. Estimates of the value of a statistical life taken from summary reviews and specific studies are widely used and multiplied by expected deaths "delayed" to obtain the mortality benefits from a particular program, investment, or other exogenous change in baseline conditions. A similar protocol is followed in using the literature on the values of avoiding acute health effects to estimate the benefits of baseline pollution reductions. Indeed, "spread sheet" and more user-friendly models that are available (e.g., RFF's Health Benefits model available in the Analytica software or Hagler Bailly Consulting's EXMOD model) first match estimates of changes in air pollution concentrations to concentration-response functions for a wide variety of health effects and then

match these to unit values for avoiding these effects to obtain health benefit estimates for environmental improvements. Table 3A-2 contains benefit estimates taken from RFF's model for a unit change in the concentration of PM10, ozone, SO2, and lead, by health end point on a per-person basis.

Mortality

Attempts at estimating the benefits associated with delaying death often evoke the comment that "you can't put a value on a life." A lead article in the *Washington Post Magazine* titled "What's a Life Worth?" criticized the Reagan Administration for even considering the topic.

That criticism of estimating mortality-reduction benefits misses the point because "lives" are not being valued; the values are for reductions *in the risks* of premature death.[18] Behavior that helps to reveal such values is not rare; it is observable every time someone takes a higher wage in exchange for a somewhat riskier job or raises driving speed to save a few minutes. Hundreds of journal articles have been written on the subject, creating a rich body of values for mortality-risk reductions, and hundreds of CBAs of regulations that affect mortality risks have relied on this literature.

The valuation literature is most voluminous with respect to estimating the willingness of people to pay for reductions in their risk of death. There are several approaches to determining such values. The hedonic-labor-market approach, applied most, involves the identification of wage premiums paid to workers in jobs that have high risks of death (Viscusi, 1992, 1993). Stated-preference methods have also been used. These methods involve placing people in realistic, if hypothetical, choice settings and eliciting their preferences (such as asking people their WTP to take a ride on a bus of a company with a better safety record than another company). These choices might involve alternative government programs or specific states of nature, such as a given reduction in one's risk of death in an auto accident associated with living in one city instead of another, riskier, city (see Krupnick and Cropper, 1992).

These methods and the studies have been extensively reviewed (see Lee et al., 1995). There is a growing recognition that the compensating-wage studies have limitations for valuing death-risk reductions in an environmental context. There are several limitations of such studies for valuing environmental risks: they reflect risk preferences of perhaps a less risk-averse group than the average in society; they reflect voluntarily borne risks; more life-years are lost to accidental death than to, say, cancer, which has a latency period, and whose effects might be

[18] The phrases "value of life," "value of statistical life," "value of lives saved," and "value of lives extended," are all basically synonymous terms for measures that permit reductions in mortality risks to be monetized. Values for these terms are derived by dividing an estimate of the value for avoiding (or obtaining) a given change in the risk of death by the risk change. As lives cannot be "saved," of course, we prefer the terms extended and shortened.

discounted because they occur far into the future; and the source of the risk is an accident, rather than, say, a business that pollutes as part of its normal operations.

To address some of those issues, Mitchell and Carson (1986), in their contingent-valuation study, examined the relationship between WTP and reductions in a cancer-causing substance--trihalomethane--in drinking water. It asked subjects for their WTP to avoid increased risks of a disease that has a latency period and generally affects older people. Few other studies have followed that path; this study, which was a pilot involving fewer than 300 people, cannot be solely relied on for such important values. Other stated-preference studies--such as Jones-Lee et al. (1985), Viscusi, Magat, and Huber (1991), and Krupnick and Cropper (1992)--were targeted to accidental-death risks, rather than mortality risks in an environmental context. However, one recent study (Johannesson and Johansson, 1995) addresses several of these issues by asking 35- and 65-year-old people their WTP for a government program that could increase the length of their life by 1 year. The exceedingly low estimate ($2,500) raises questions about the survey, in particular, the instructions that the subjects would otherwise have average life expectancy (with certainty) with the additional year known with certainty.

Some studies, including Johannesson and Johansson, have attempted to distinguish age-specific WTP, to line up better with the epidemiologic literature that shows that air pollution risks vary by age group. Hagler Bailly Consulting (1995) used the small literature that relates age of mortality-risk onset to WTP to adjust the average value of a statistical life ($3.5 million) to those older than 65 ($4.0 million) and those younger ($3 million). More substantive progress will require a more basic understanding of how people perceive mortality risks associated with pollution.[19] Risk perceptions have been shown in a vast literature to be based on many attributes of a commodity beyond the "quantitative" risk it poses (Slovic, 1992; Cropper and Subramanian, 1995), such as dread, source of the risk, voluntariness, and controllability. Yet this literature generally has not taken the logical next step of relating WTP for risk reductions to such nonquantitative factors[20], nor has the environmental economics literature made much of an attempt at such integration. An exception is McDaniels et al. (1992), who explain WTP for risk reductions with qualitative risk attributes. Unfortunately, that study describes the quantitative dimensions of the risk in rather vague terms (percentage changes in risk), which limits its usefulness for sorting out the effects of quantitative and qualitative influences on value. Research on this topic continues.

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[19] See Horowitz and Carson (1993) for a study showing that the WTP for a risk reduction depends on the baseline risks posed by the activity whose risk is being reduced.

[20] Slovic (1992) recognizes the need for this type of research when he writes, "More generally, there is a need for research that determines how the public feels about incorporating risk perception characteristics as explicit criteria that are traded against cost and more traditional criteria (e.g., lives and health effects)" (p. 151).

Morbidity Valuation: Acute

The ideal WTP measures would capture all the medical costs, pain and suffering, time loss, and fear of an acute illness (see Harrington and Portney, 1987, for the basic model). In principle, the stated-preference approach can come closest to reaching the ideal. Three contingent-valuation (CV) studies (Loehman et al., 1979; Tolley et al., 1986a; Dickie et al., 1987) have used bidding procedures to elicit estimated values for respiratory-symptom days, with average estimates ranging from $1 to $25 or more, depending on the symptom, its severity, and whether a complex of symptoms is experienced.

All those studies have drawbacks, related mainly to their age--the CV studies were performed before many of the most important advances in CVMs. But they offer consistent ranges of estimates for WTP to avoid a particular type of symptom. A more- recent study is that of Alberini, Cropper, and Krupnick (forthcoming), which surveys a sample of Taiwanese about their WTP to avoid their most-recent episode of acute respiratory illness. This approach differs from that of other studies in generally describing the symptoms and duration of the episode for the person. Statistical techniques are used to relate the Alberini-Cropper-Krupnick values to the duration and severity of the episode and other variables, and the results are compared with those of the older studies. Even though the Taiwanese have lower incomes than the people participating in the US studies, the Taiwanese WTP is larger per symptom-day.

There are several alternative approaches to valuing acute health effects. One--the cost-of-illness approach--attempts to tally the various out-of-pocket costs associated with illness. By missing "pain and suffering," this approach necessarily underestimates the full costs. Hospitalization, emergency room, doctor, and drug costs (including charges paid by insurance companies), the value of nonwork time spent in these activities and being sick, and the value of work lost as a result of illness are the categories of costs usually estimated.

Another, less-used approach---the averting-behavior method--attempts to infer the WTP to avoid a health effect by observing and placing a value on behavior used to avoid the health effect. For instance, if someone stays indoors with the air conditioner on all day *because* of high pollution, the added costs of the electricity bill might be related to the WTP to avoid the health effect. For this approach to yield defensible estimates of value requires a number of stringent assumptions. In practice, it is little used, particularly in an acute-health context. See below, however, for a good example in a chronic health context.

Morbidity Valuation: Chronic Effects

This segment of health valuation has been the most active recently. Viscusi, Magat, and Huber (1991) and Krupnick and Cropper (1992) used conjoint analysis to examine the WTP to reduce the risks of chronic respiratory disease. This analysis involves asking subjects to choose between two cities to live in, where both are preferred to a respondent's present city and the cities differ in the risk of developing chronic bronchitis (or respiratory disease in general) and in one other characteristic: the probability of dying in an automobile accident, or

the cost of living. An interactive computer program changes the magnitudes of these differences to drive the subject to a point of indifference between the two cities. At this point, the tradeoff between automobile-related death and chronic bronchitis is known, and a statistical case of chronic bronchitis can be monetized by using a value of a statistical life, or, for the tradeoff between chronic bronchitis and cost of living, the value of a case can be obtained directly. The two studies use the same protocol, except that Krupnick and Cropper chose a sample of subjects who had relatives with chronic respiratory disease and asked a second set of questions to obtain WTP to reduce risks of a chronic respiratory disease with symptoms *just like their relative's.*

Dickie and Gerking (1996) use a household production model to address WTP to avoid skin cancer. With this model, people combine consumption goods, goods to reduce harmful effects of sunlight, and time spent in the sun and in other places to produce satisfaction. The model is formulated to permit risk perceptions to influence averting behavior, which then influences WTP. In a contingent-behavior survey of 300 people eliciting WTP for a lotion that reduced skin-cancer risks, average WTP varied by perceived baseline risk and income, from $30 to $50 for a 5% reduction in lifetime skin-cancer risk. At the true risk level (1 in 7), this value is $44, or $6,160 ($44/0.007) for a statistical case (in 1988 dollars).

3.A.2.b Ecosystem Valuation

Ecosystem valuation covers a multitude of potential contributions to human well-being. Biological diversity gives rise to many values. Diverse ecosystems are sources of new commercial products and are essential in water and nutrient cycling, climate moderation, and protection against soil erosion. Biodiversity is also valued for difficult-to-measure, but real and important, ethical and aesthetic reasons. These ecosystem values depend on other factors besides biodiversity; in particular, they depend on *how* the parts of an ecosystem interact.

Of these sources of value, economists have devoted the most attention to biodiversity as a source of new commercial, agricultural, and particularly pharmaceutical products. A number of such studies have posited some probability of success in the testing of any particular sample as a source of a new commercial product. The value of a collection of species is, then, taken to be the product of the probability of success, the payoff if a new product is developed, and the number of species in the collection. Farnsworth and Soejarto (1985), Principe (1989), McAllister (1991), Harvard Business School (1992), Pearce and Puroshothamon (1992), and Aylward (1993) have used this approach. Results of these exercises range from as little as $44 per untested species in situ (Aylward, 1993) to as much as $23.7 million (Principe, 1989). Simpson, Sedjo, and Reid (1996), using a model allowing for the possibility that different species can be used for the same purpose, estimate an upper bound on the value of the marginal species for use in pharmaceutical research at less than $10,000 and argue that a reasonable estimate of this value, as opposed to the upper bound, could be much lower.

Considerably less work has been done on the valuation of the other economically important services and products generated by biodiverse ecosystems. Some economists doubt that the tools of the profession can be applied to the valuation of biodiversity:

> The economic framework, with its focus on the welfare of humans, is inadequate to the task of valuing such things as biodiversity, the reduction of ecological risks, and the protection of basic ecosystem functions. When policies to protect biodiversity or ecosystems are proposed, economists may be able to say something sensible about the costs of the policies, but . . . economists will not be able to contribute comparable welfare measures on the benefit side of the equation. [Freeman, 1993, p. 485]

Although it cannot be denied that great uncertainties are involved, such pessimism might not be entirely warranted. Ecologists are likely to improve their ability to describe and predict the function of stressed ecosystems. As these natural-science data become more reliable, economists might be better able to assign values to what are now poorly understood ecological functions and services.

3.B Costs

This section addresses the cost side of the cost-benefit ledger. Our intention is to lay out the conceptual foundations for cost estimation, to show that the foundation is the mirror image of the foundation on which benefit estimation lies, and to discuss some of the features of cost estimation that are often overlooked in cost-benefit studies. As the reader will see, the estimation of cost is as difficult an undertaking as the estimation of benefits--something not often recognized by even the most knowledgeable practitioners of CBA.

This section is composed of six parts. In the first, we define *cost* and note that the correct conceptualization of cost is not *compliance cost*, but rather the change in social welfare associated with compliance cost. In the second, we equate cost to *lost opportunities* and suggest that the proper identification and quantification of cost should be guided by the lost-opportunity concept. The third concerns *general equilibrium* effects, that is, the effects of a policy that extend beyond the direct object of the regulation.[21] In addition to general equilibrium effects, government policies can have dynamic implications, that is, effects that can impose costs because of alterations in the intertemporal decisions made by producers and consumers. The fourth part discusses these dynamic effects. Although much attention has been paid to the costs of command-and-control policies, policies based on economic incentives also have costs, and they are dealt with in the fifth part. The sixth part summarizes the section and presents some concluding comments.

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[21] General equilibrium effects are sometimes referred to as secondary effects.

3.B.1 Monetary Measures of Reduced Well-Being

Measuring the costs of a policy is identical with measuring its benefits in the sense that in CBA we are concerned only with changes in individual welfare that we will aggregate to changes in social welfare. Bearing in mind that measuring cost means measuring changes in social welfare clarifies our thinking about what is a cost, where we should look for costs, and how we should measure them. For example, the most popular concept of regulatory cost in the analysis of environmental programs is abatement expenditures, i.e., out-of-pocket costs for abatement equipment. This is an exceedingly narrow measure and might have little to do with a better, but still imperfect measure--compliance cost, i.e., the cost of all the actions necessary to comply with a particular policy. For instance, a new environmental regulation might contribute to a change in how a product is made. This would not show up an abatement expenditure but would be a compliance cost. Even here, although the cost of compliance can have a bearing on monetary measures of well-being changes, there is no simple conceptual link between the two.

The inadequacy of compliance cost as a surrogate for changes in well-being was identified by Hazilla and Kopp (1990), who presented a study of the costs of the Clean Air and Water Acts. With a dynamic computable-general-equilibrium (CGE) model developed for the study, Hazilla and Kopp used EPA information on the actions taken to comply with environmental regulations to measure the monetary changes in aggregate social welfare that came about as a result of those actions. (The use of general equilibrium methods is discussed further below.)

Table 3B-1 displays the monetary estimate of the loss in well-being alongside the EPA compliance estimates for selected years and over a 10-year period.

TABLE 3B-1. Annual Estimates of Monetary Changes in Well-Being and EPA Estimates of Compliance Cost for the Clean Air and Water Acts (billions of Current Dollars)

Year	Monetary Measure of Change in Well-Being	Compliance Cost
1975	6.8	14.1
1981	28.3	42.5
1985	70.6	56.0
1990	203.0	78.6
1981-90	977.0	648.0

Source: Hazilla and Kopp, (1990).

The table reveals that monetary estimates of lost well-being are less than compliance costs in the early years after enactment of the Clean Air and Water Acts, but grow to exceed compliance costs in the out years. The remainder of this section uses the Hazilla and Kopp study to point out important concepts and empirical aspects of cost measurement.

3.B.2 Cost as Opportunities Forgone

Cost ultimately means a forgone opportunity, that is, something that was given up as a result of the policy. That is perhaps the most important rule to follow when doing a cost analysis of a public policy. Take, for example, the policy to ban ozone-depleting substances. The action that the policy brought forth was the development of products to replace popular chlorofluorocarbons (CFCs) like freon. Where would one look for the costs of this policy? The costs could be found in any of the following:

- The diverted resources necessary to develop the substitute products. In this instance, firms that were producing freon were forced to redirect resources from other activities (most notably R&D and product development) to find a substitute for freon. This redirection of resources led to the development of a substitute, but society lost the value of the R&D and product development that was sacrificed to produce the substitute.[22]

- The value of services of specialized capital (such as machines that can be used only to make freon) and technology necessary to manufacture the banned products. In general, if the manufacture, transport, marketing, and sale of the substitute product require capital, talent, and organizational infrastructure different from those required for freon, then the value of the freon-based capital, talent, and organizational infrastructure is lost and is a cost to society.

- Increased costs of production for the replacement product vis-à-vis the banned product. If the replacement product is more costly to produce than freon, the added cost of production (additional factors of production drawn from society's limited stock and thus diverted from other activities) is a loss in social well-being and thus a cost of the policy.

- Differences in the retail price of the replacement product. If the price of the replacement product rises above the price of freon, then consumer welfare is reduced. Economists generally measure this as a loss in consumer surplus, which is to say a loss in the well-being of the individual and a properly accounted cost of the policy.

- Decline in the quality of the replacement product. If the replacement product is less effective than freon, then in addition to a price rise the consumer receives a less valuable product, again causing a loss in well-being.

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[22] Unfortunately, at the present time we do not know what projects were placed on hold or canceled as a result of the R&D redirection, and thus we do not know the opportunity costs of this redirection. This is not to say that research could not be undertaken to uncover these costs.

- Other market effects. To the extent that the ban affects other markets (e.g., refrigeration manufactures that are required to develop new products that are capable of using the replacement chemicals), the same cost analysis would be repeated in these markets.

The enumeration of cost categories emphasizes that the total compliance cost of regulation consists of more than direct compliance cost. Some economists have argued that is possible for regulation to have positive offsetting effects as well, by stimulating productivity increases or promoting innovation. However, that claim is hotly disputed by other analysts. We pursue this point further below.

3.B.3 General Equilibrium Effects

Some forms of regulation can be quite narrow in the range of responses they engender. These regulations tend to be tightly focused on target activities (e.g., selected industrial sectors) and do not spill over into sectors that are not direct targets. However, depending on the nature of the activities to be regulated and the magnitude of the responses required, secondary effects of the policy can be felt beyond the direct target of the policy. When secondary effects are *de minimis*, they can be ignored in a cost study, and economic techniques of *partial equilibrium* analysis may be properly applied.[23] However, when secondary effects are thought to be large, a *general equilibrium* analysis is called for.[24]

The importance of considering secondary effects can be seen by returning to the Hazilla and Kopp study. It reveals that although pollution control investments were required in only 13 of 36 U.S. production sectors, the cost of production increased and output and labor productivity decreased in *all* production sectors of the U.S. economy as a result of the Clean Air and Clean Water Acts. A good example of the magnitude of the secondary effects is found in the finance, insurance, and real estate sectors of the economy. The finance sector was not required to invest in pollution abatement equipment and obviously did not incur higher operating costs as a *direct* consequence of the acts. It would thus not appear to bear any costs under a compliance-cost, partial-equilibrium approach to cost estimation. However, on the basis of the more appropriate general equilibrium analysis, the cost of production in the finance sector was 2% higher in 1981 as a result of the indirect impacts of the regulation--more specifically, as the result of higher factor (input) prices.

Unfortunately, there is no easy way to tell when a policy will require a full general equilibrium analysis and when a partial analysis will do. Most likely, regulations that affect highly integrated sectors of the economy, such as sectors that produce widely used intermediate products (like energy), will require general equilibrium analyses. Policies that

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[23] A partial equilibrium analysis would focus on a narrow set of economic agents (producer and consumers) and would assume agents outside this set would be unaffected by the policy.

[24] A general equilibrium analysis makes no assumptions about affected parties and treats all agents in the economy as if they could be affected.

generate large direct costs may also call for a general equilibrium approach. Other than these rather crude rules of thumb, little direct guidance can be provided. However, because a partial analysis is just a special case of a general equilibrium analysis, agencies can err on the side of caution and conduct a general equilibrium analysis, even if it turns out that a partial analysis would have been sufficient. Inasmuch as a general equilibrium analysis can be relatively expensive, agencies should develop and maintain a CGE model for regulatory purposes, allowing general equilibrium analyses to be routinely and cheaply performed.

3.B.4 Dynamics

In this section, we want to differentiate between decisions and actions that have intertemporal consequences and decisions that do not. Producer decisions and actions that might have intertemporal consequences would be those affecting investment (including investments in physical and human capital and R&D); on the consumer side, we have savings, human capital investments, durable-goods purchases, and factors that influence household labor supply. Policies that alter these decisions can alter the growth path of the economy. To the extent that the growth in factors important to individual well-being (e.g., personal income) is diminished by a policy, the cost of the policy (measured in terms of lost well-being) increases over time. For example, personal disposable income in the first quarter of 1995 stood at $5,184 billion, an increase of 4.5% over 1994.[25] If income grew at 4.5% per year until 2000, income would be about $6,461 billion in the first quarter of 2000. However, if a policy were implemented that did nothing but diminish the rate of income growth by 1/2%, the cost of the policy in the year 2000 would be in excess of $153 billion.[26] Five years later, in 2005, the cost would rise to $377 billion!

The above example demonstrates how sensitive cost is to alterations in the economy's growth path. Even small changes in growth are compounded and can lead to large costs. Of course, it could be that regulation rarely affects intertemporal decisions and therefore is unlikely to affect the economy's growth path. However, for any particular regulation, we do not know *a priori* what intertemporal impacts will be forthcoming.

For a concrete example of intertemporal growth effects, consider again the Hazilla and Kopp study. The study used a CGE model to simulate the behavior of the U.S. economy over a 20-year period from 1970 to 1990. In the *base* simulation, the economy was modeled without the Clean Air and Water Acts, whereas the *scenario* simulation included the effects of the acts. Table 3B-2 compares the percentage differences in some macroeconomic variables between the base and the scenario at two points, 1981 and 1990.

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[25] *Federal Reserve Bulletin*, January 1996, table A52.

[26] This does not count the losses in each year 1995-2000.

TABLE 3B-2. Percent Change in Selected Macro Variables Between Base and Scenario

Macro Variable	1981	1990
Real Consumption	-2.68	-6.53
Real Gross Private Domestic Investment	-4.15	-8.35
Real Gross National Product	-2.43	-5.85
Real Private Domestic Capital Stock	-2.02	-5.96
Real Household Labor Supply	-0.84	-1.18

Source: Hazilla and Kopp, 1990.

The important thing to note from Table 3B-2 is that the percentage differences in the macro variables are growing. For example, in 1981, real consumption was 2.68% less in the scenario (with regulations) than in the base. In 1990, the difference had grown to 6.53%, indicating that real consumption was growing less rapidly in the scenario than in the base; therefore, as time passes, the absolute differences in real consumption become larger.

Hazilla and Kopp trace the growing disparity between base and scenario to alterations in intertemporal decisions. They state:

> Consider the changes in levels of investment, capital stock, and labor supply brought about by the regulations reported in the table. The factor underlying the decrease is the household labor supply decision. In this case, since the relative price of consumption to leisure has increased, labor supply declines under the post regulation scenario. Reduced labor supply also induces a decline in income and saving. The decline in saving causes investment to fall and, with it, capital stock growth. While supplied labor hours and capital availability increase over time under the regulatory scenario, both increase at a diminished rate. Consequently, household real income declines and aggregate economic growth is retarded.[27]

As noted previously, some analysts believe that the cost of regulation is overstated, in that no allowance is made for increases in productivity and innovation spurred by the need to comply with the regulation. In part, this issue turns on the extent to which the form of the regulation provides incentives for innovation, as indicated in the next subsection. In addition, one must be prepared to argue that prior to implementation, resources devoted to technological change and productivity enhancement (for example, R&D expenditures) are

[27] Hazilla and Kopp (1990), p.867, 870.

deployed inefficiently (perhaps because of market imperfections) and that the regulation will provide incentive to deploy those resources more efficiently.[28]

3.B.5 Incentive-Based Policies

It is very popular to argue that regulation can be made considerably more efficient (i.e., less costly) by switching from traditional command-and-control regulation (which still predominates in U.S. environmental regulations) to incentive-based regulation.[29] One commonly analyzed incentive approach is the emission fee, a tax on the polluter based on the magnitude of pollution. The carbon tax, often talked about in policy discussions of carbon dioxide control, is such a tax. Emissions trading is another commonly considered form of incentive policy.

An incentive-based regulatory system generally provides polluters the flexibility to find the cheapest means of compliance, but one should not infer that the regulation comes at little or no cost beyond the direct cost of compliance. The cost of tax-based incentive approaches (or equivalent trading programs) ultimately comes from the fact that all tax systems alter behavior, whether or not that is their intention; no practical tax system is perfectly efficient.[30] The altered behavior can lead to dynamic costs similar in origin to the dynamic effects of command-and-control regulation uncovered by Hazilla and Kopp, whereas the inefficiency of the tax system can lead to what economists term dead weight losses.

As an example of a cost analysis of an environmental taxing policy, we refer to Jorgenson, Slesnick, and Wilcoxen (1992). They examine the costs of alternative tax schemes designed to reduce and stabilize U.S. emissions of carbon dioxide at 1990 levels by the year 2000. The authors use a CGE model akin to that used by Hazilla and Kopp and report the cost of the tax policies in terms of monetary loss in aggregate well-being. They find that well-being is $187-250 billion (1990 dollars) less in the year 2020 with the carbon tax than without it. This cost is due almost entirely to a lowered rate of capital accumulation in the economy.

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[28] Compare for example, Porter and van der Linde (1995) and Palmer, Oates and Portney (1995).

[29] In the context of environmental regulation, command and control policies establish specific emission or other behavioral constraints on individual sources of environmental hazards, backed by the threat of legal sanctions for noncompliance. The standards are only weakly tailored at best to individual compliance costs, and they may in fact be explicit or implicit requirements for the use of specific technologies (the latter occurs, for example, when the standards reflect "best available technology"). Incentive-based policies, in contrast, provide greater flexibility in the mode of compliance, relying more upon economic motivations to stimulate compliance.)

[30] Pollution fees are taxes intended to alter behavior, reduce emissions of pollution, while revenue raising taxes like the income tax are not intended to alter behavior, only to raise revenue. Unfortunately the income tax does alter behavior in many undesirable ways.

The caveat noted above about technical change applies here as well, in that incentive-based policies by their nature do provide incentives for improved technology. In addition, the economic burden of a tax policy will depend in part on how tax revenues are used (the cost will be lower if other distorting taxes are reduced). Nevertheless, while incentive-based regulatory approaches might be less costly than command-and-control approaches, they, too, can be quite costly.

3.B.6 Conclusion

Although most benefit analyses have generally followed the conceptual foundations of welfare economics--that is, they have as a goal the monetization of enhanced well-being--few cost studies can claim to be consistent with welfare-theory tenets. If one desires to use cost-benefit analysis as a normative tool for public decision-making, consistency with economic theory is not an option to be adopted or rejected at the whim of the analyst. Consistency is a necessary condition if normative statements are to be made on the basis of cost-benefit studies.

3.C Addressing Uncertainties

In principle, the appropriate approach to handling uncertainties involves two steps. Estimates of the total present discounted benefit distribution and the discounted cost distribution are compared to yield a net benefit distribution associated with the given scenario. This distribution, evaluated according to some decision rules and compared with net benefit distributions from other scenarios, permits an efficient scenario to be identified, at least within the confines of the analysis.

The standard approach in CBA for comparing distributions of net benefits is expected utility theory, in which each potential state of the world generates a particular net benefit, and the utility of these net benefits is weighted by their likelihood of occurrence and summed. The structure of this utility function in part reflects the attitude of members of the society toward risk.

In recent years, this approach to describing valuation of uncertain outcomes has been criticized. Critics argue that individuals ignore or systematically misestimate risks, especially low-probability, high-consequence events; that individuals' valuation of risky situations is influenced by their frames of reference; and that perceptions of risky outcomes are affected by concerns about ex post regret as well as expected utility (see Camerer and Kunreuther, 1989, for an extensive review of these and other issues). However, these criticisms are by no means universally accepted, and alternatives to expected utility also have not won widespread acceptance. For the time being, CBA will continue to be based on calculation of net benefits, with adjustments for the cost of risk-bearing, while research continues.

The analysis of uncertainty can be conducted within this framework with Monte Carlo simulation techniques. These techniques involve characterizing uncertainties in input data, equation parameters, and other features of the analysis with probability distributions; using random samples of each of these distributions in the designated calculations to generate so-called realizations; and using the realizations to form probability distributions of the output

variables. These distributions reflect the uncertainties within and between the appropriate stages of the analysis.

In practice, the full representation of uncertainties is often ignored in favor of more ad hoc approaches, such as the representation of some output variables by their expected values and of others by "low," "middle," and "high" values (say, by the values representing the 95% confidence interval around some expected value). These are then paired with their corresponding values from the next stage of the analysis. The result is a set of "low," "middle," and "high" values for the final output (say, the benefits of a waste cleanup) that do not correspond to any particular confidence interval and thus can be very misleading.

4. IMPROVING METHODS FOR REGULATORY ANALYSIS

4.A Guidance on Risk Assessment for CBA

Economic analysis of the benefits of environmental improvements is generally thought of as being at the end of a chain of a set of analyses collectively known as risk analysis. Risk analysis includes the standard four stages of hazard identification, dose-response analysis, exposure analysis, and risk characterization. The last stage integrates the data from the dose-response and exposure analyses to estimate the expected level of risk posed in the particular scenario being examined. It is this change in risk of a particular health or environmental end point, such as a case of cancer, that is available to the economist for estimating benefits of the scenario. This section explores the requirements for risk analyses if economic analyses based on risk analyses are to be consistent with principles of CBA.

Before proceeding, however, it is worth noting that the economist has some tools that value risks indirectly, without using estimates of health effects or other environmental end points. For instance, hedonic property value studies estimate the relationship between housing prices and other characteristics, such as local pollution levels, that might influence price. To the extent that buyers and sellers of property are aware of the risks to health and other end points posed in various locations, such risks will be capitalized into the price. Hence, we clearly observe that houses near airports are priced less than otherwise identical homes that are farther away. The noise associated with the planes is reflected in a price discount. Such price effects have also been observed with respect to particulate concentrations in the air and housing near municipal landfills and toxic waste sites. In this case, the buyers and sellers are, in effect, doing the work of the risk analyst and the economist in their market decisions that reflect the desirability of houses in various locations.

These approaches economize on information and respect the principle of consumer sovereignty in inferring economic values, but they are less reliable when multiple types of effects are involved, when effects are not readily apparent, or when effects are not tied so closely to market transactions. There is no easy way to separate out the visibility and health effect risks associated with air pollution concentrations, for instance, although in some applications such a separation would be less critical; for example, to the extent that visibility degradation and health risks are joint products, housing prices might partly reflect both kinds

of pollution risks. There is also a partly philosophical issue, which we take up below, regarding the use of lay risk assessments potentially based on incomplete or inaccurate information and the use of more "informed" expert risk assessments. For example, can lay people be presumed to understand the long-term mortality-risk differential of living in an area with somewhat higher particulate concentrations than another area? What about their understanding of acute health risks? Clearly, those who believe that government policies should be driven by expert assessments will reject the indirect valuation approach.

Turning now to the requirements for risk analysis to be consistent with CBA principles, we offer the following suggestions:

4.A.1 Match Risk Characterization End Points with Valuation Start-Points

The health and biological science paradigm that underlies a risk assessment might conflict with the needs of the economist in that the risks being evaluated by the scientist might not be meaningful to the person who is asked, at least implicitly, to provide preferences for avoiding such risks. A classic pollution-health example is the "lung function" end point. The change in lung function is a favorite end point for clinical and epidemiological studies because it is easily measured. But, a 10% improvement in lung function is not meaningful to most people. They do not demand greater lung function; they want fewer sick days and a lower risk of developing chronic respiratory disease. Consequently, there will be no economic studies to provide values for the lung function end point. Close collaboration between economists and scientists who are estimating concentration-response functions and the government agencies funding their efforts can help to avoid this type of mismatch.

4.A.2 Risk Targets vs. Dose-Response Relationships

As noted previously, CBA (and economics generally) is about evaluating the consequences of changes in some stream of services. In the context of assessing changes in risk, the economics paradigm attempts to assess the economic value (as represented by WTP) of changes in risk, where the change in risk is in turn a function of changes in some harmful substance or circumstance. In the context of health risks, knowing how changes in concentrations of or exposure to a harmful substance alter the probability of illness or premature death allows the economist to attempt to value WTP for this risk reduction. Hence, the economic paradigm relies heavily on some kind of dose-response description of risk.[31] This approach, for example, underlies the extensive literature on the environmental benefits of reduced levels of criteria air pollutants referred to in Section 3 above.

The risk assessment paradigm often has a very different direction, namely the establishment of a single target concentration or exposure that can be regarded as providing an

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[31] These relationships often are assumed to take a simple linear form, indicating some risk even at trivial concentrations of pollutant or levels of exposure. However, alternative formulations certainly are feasible and credible, including threshold levels below which there does not appear to be any significant risk.

acceptably small risk, e.g., a "no-observed-adverse-effect level" of a contaminant in an environmental medium or food product. The establishment of such an acceptable level of contamination involves a mixture of scientific analysis, scientific opinion, and value judgments and is one way (not the only one) for society to establish environmental quality objectives or aspirations. It can seem particularly appealing when the data and science for understanding dose-response relationships are poor, as is often the case. However, the establishment of such a single target concentration or exposure necessarily precludes economic analysis of alternative standards, such as a comparison of the target to the status quo. Moreover, the embedding of value judgments about "acceptable" risks into the establishment of the target works at cross purposes to the goal in CBA of inferring appropriate levels of protection from individual preferences.

Therefore, for risk assessments to provide information that can be used in CBA, it is important to enlarge the capacity to express how risks vary with changes in concentration or exposure--whether this is done through basic research on cell physiology or through additional epidemiological studies. It also is important to incorporate both economic and scientific information into the judgments that determine environmental, health, and safety standards. We develop this point more fully in the next section. To illustrate the point, we draw attention to recent Congressional efforts to reauthorize the Safe Drinking Water Act, under which health-based goals continue to be used but the degree to which they are achieved reflects a balancing of health risks with compliance costs.

4.A.3 Estimate Population Risk, Not Individual Risk

Another evident feature of risk assessments--one driven more by regulatory needs than any scientific prerogatives and one that conflicts with the needs of the economist--is the focus on estimating individual risk rather than population risk. By individual risk, we mean the risk posed in some scenario to a hypothetical individual (often a "worst case" or a "maximally reasonably exposed individual"). Population risk, alternatively, is the risk posed by some scenario to the entire population, which may be estimated by multiplying a unit risk associated with a change in exposure of each population segment by the population in that segment.[32]

The economic paradigm leads to estimating benefits for the population at large. If costs are to be compared with benefits, it would make no sense to compare the total costs with the benefits experienced by only one (hypothetical) individual. Even if one were performing a cost-effectiveness analysis, where abatement costs per risk to the maximally exposed individual were being estimated, individual risk estimates could generate paradoxical results. Suppose that one abatement strategy yielded a very high individual risk reduction but a low population risk reduction (because few people were exposed to the pollutant of concern), and another

[32] The unit risks for different population segments typically will themselves be uncertain. To construct a population risk distribution these uncertainties should be taken into account using statistical estimates or sensitivity analysis methods.

equally costly strategy reduced the risk to many more people but the individual risk reduction was smaller. A cost-effectiveness analysis based on individual risk would lead to the first strategy's being adopted over the one based on the population risk, although the latter strategy could generate greater total benefits.

4.A.4 Worst-Case vs. Measures of Central Tendency and Other Measures

The risk assessment paradigm builds uncertainty about risk characterization into the assumptions used to estimate risks. This paradigm, with a focus on individual risks, purposefully skews risk estimates upward to build in a margin of error and protection in policies that are geared to protecting the population from risks.

The economic paradigm, contrary to popular belief, does not argue for decisions based on the expected risks (or benefits or net benefits) but argues, instead, for separating the distribution of risks to the population from estimates of risk aversion. With this paradigm, the analyst attempts to describe the distribution of risks (or the distribution of risk improvements) in the population and leaves it to the decision-maker to decide which strategies deliver an acceptable degree of protection. In a sense, then, the risk assessor's use of "worst case" estimates provides one point on the risk distribution. Decisions based on worst-case analysis are not precluded. But the decision-maker is presented with other options.

4.A.5 Expert vs. Lay Risks

Risk assessment relies on expert assessments of risks. That is not to say that in cases where the public and the experts disagree over the size of the risks, such as the assessment of the future of nuclear power, the public views are ignored. Rather, the public risks are not given the same standing as expert risks and are not formally considered in a risk assessment.

In the economic paradigm, individual perceptions about the risks associated with products and activities are treated as given, and the economist's job is to construct the preferences for such products and activities conditional on those perceptions. Suggestions that the public holds incorrect perceptions often are viewed with some skepticism, at least when the public can be presumed to be reasonably familiar with the "good" being perceived. Economists argue that while one should provide better and less expensive information to the public to improve their choices, public perceptions have standing for decisions being made today and particularly for choices that have market consequences (as in the property market example above). The results of CBA always are conditional on the information possessed by those whose preferences are being assessed, and it is important to distinguish valuations conditional on baseline information from the value of additional information. Such positions are echoed by behavioral psychologists and sociologists who note the multidimensionality of risks in

individual "mental models"--incorporating trust, controllability, dread and other concerns that are outside the purview of an expert risk assessment.[33]

The distinction between experts' and lay people's assessments of risk does not mean that either is incorrect. Because economic estimates of damages are estimated on the basis of *individuals'* WTP to avoid risks, one could argue that it is appropriate to estimate damages of potentially catastrophic accidents on the basis of lay perceptions of risk, inasmuch as lay people's WTP is based on *their* perceptions. However, that can lead to dilemmas when there are good reasons to doubt the accuracy of lay assessments. Such dilemmas can be resolved only when criteria for the "appropriate" degree of information and accuracy have been developed. Analysts can address this issue in some cases by attempting to assess the value of additional information and the consequences for choices of additional information. That can be done through direct experiments or by trying to isolate in the data the effects of information differences on choices.

4.A.6 Baselines

The baseline is a term for a state of nature in the absence of a contemplated policy intervention. The net benefits of a policy are often measured as the difference between situations with the policy and without the policy, and the assumptions and estimates underlying the baseline can be as influential as the policy itself in determining net benefits.

This issue applies to risk assessment as much as to CBA, however. A good example is Superfund cleanup. Although a lot of attention is paid in a risk assessment to establish a baseline level of risk at a site in the current year, virtually none is paid to establishing how that risk will change in the absence of policy intervention, i.e., how the baseline risk will change intertemporally. If an affected aquifer is self-cleansing, risks might fall, with the consequence that any cleanup will be less beneficial, because there will be less risk to reduce. Krupnick, Spofford, and Wood (1989), in their analysis of the Woburn, MA, Superfund site, find that the contaminated wells have just this intertemporal pattern of self-cleansing, making all but the least-expensive and fastest-acting remediation approaches not cost-effective. No CBA of such a cleanup can be properly conducted unless risks under the intertemporal baseline situation are fully specified.

4.A.7 Substitution Risks

There has been little attention in risk assessments to tracking and estimating substitution risks, i.e., the new risks that arise as a consequence of policy. An example is the risk of bacterial infection that arises when high VOC-content antibacterial household cleaning products are banned to help to control ambient ozone and, as a result, risks of foodborne

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[33] Here, there is some overlap between ignoring risk aversion and ignoring lay risks, as some of the "extra-risk" attributes, such as "dread," may properly be classified under risk aversion.

contamination rise. In contrast, in CBA, the paradigm is to cast the net widely to encompass a broad range of potential benefits and costs.

It is reasonable to presume that the lack of attention to this issue in risk assessments arises from the need for, but the absence of, economic analysis to determine how and how much a given policy will alter behavior and which substitution risks are more important to consider. For instance, the risk reduction from banning a pesticide can be estimated in a risk analysis, but the estimate of the added risks from using more or different unbanned pesticides cannot be estimated without a model to predict farmer decisions about crop types and inputs, including pesticides. Here is a subject on which economists and risk assessors must work together if the entire consequences of a policy are to be appropriately described.

4.B Guidance on CBA Methods

4.B.1 OMB Guidance

Every administration since President Kennedy's (if not before) has sought to oversee the economic consequences of its regulatory actions. Sometimes this oversight has taken the form of special commissions or review groups; more recently, such responsibilities have been lodged on a continuing basis in the Office of Information and Regulatory Affairs (OIRA) of the Office of Management and Budget (OMB). To help the agencies to consider economic consequences and to guide OMB in its reviews, presidents from Jimmy Carter on have issued executive orders on this topic. Executive Order 12291, signed by President Reagan in 1981, was the first to codify requirements for agencies to evaluate the benefits and costs of regulations under OMB oversight and to show that the benefits of a proposed regulation outweigh its costs.[34] In response, OMB issued guidelines that detail how the provisions of the executive order are to be carried out.

President Clinton's Executive Order 12866 superseded the Reagan executive order, replacing the "outweigh" criterion with a more complex set of decision criteria. Nevertheless, the Clinton order still endorses CBA as a tool for helping to choose among alternative regulatory (and nonregulatory) options. Under Section 1(a) of E.O. 12866, agencies are to "include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. . . . Agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health, and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach." Section 1(b)(6) of the order directs agencies, to the extent permitted by law and where

[34] Past administrations have instituted processes and issued Executive Orders related to the costs and benefits of rules. In particular, the Carter Administration issued E.O. 12044 requiring agencies to perform regulatory impact analyses to analyze the "economic consequences" of alternative rules costing the economy more than $100 million per year (or causing major price increases) and to choose the least burdensome option. Unlike E.O. 12291, it did not require formal cost-benefit analysis. See V. Kerry Smith (1987).

applicable, to choose regulations whose benefits "justify" their costs, recognizing the difficulty of quantifying important benefits and costs. Section 1(b)(5) requires agencies to seek cost-effective policies. Section 1(b)(7) requires decisions to reflect the best reasonably obtainable information.

In the wake of E.O. 12866, OMB has revised its guidelines on regulatory analysis to reflect both the modification of the decision criteria in the Clinton order and advances in economic analysis since the Reagan guidance was established. The guidelines identify the key basic steps that agencies must take in assessing regulatory actions.

Every circumstance has its own special requirements, but there are several basic steps that any analysis must include and issues that it must address to shed light on the benefits and costs of regulation.

4.B.2 What is the Market Failure? Where are the Response Options?

A basic tenet of the economic approach to regulatory assessment is that a successful regulation improves on the allocation of resources that would otherwise arise. To be able to describe the benefits of regulation, therefore, the first step is characterizing the market failure.[35] Sometimes, as in the case of pollution spillovers, the nature of the failure is clear (although its magnitude might be uncertain). Other cases might be less clear. In the case of consumer safety, is the problem the production of unsafe products or the failure of the market to offer adequate information?

Given that the existence of a market failure is established, the set of potential response options must be identified. These can include nonregulatory, as well as regulatory, options, e.g., information provision, voluntary standards, use of fees, or tax breaks. Regulation also can be applied at different levels of government, with different levels of stringency, and to different populations. These options need to be considered in justifying a new federal regulation.

4.B.3 What Is the Baseline for Assessing the Effects of Regulation?

The answer to this question would seem straightforward in most cases: assume business as usual in the absence of the regulation. Some nontrivial judgment calls do arise, however: What level of baseline compliance with current regulations should be assumed? What future shifts in market conditions or other regulations should be considered? More troublesome is the issue of deciding what is in the baseline and what is varying in the policy analysis when multiple regulatory actions are under consideration. Here it is necessary to ensure consistency in assumptions that affect benefits and costs and to avoid self-serving hypotheses. To illustrate, suppose that a particular pollution standard would require a mixture of lower-cost and higher-cost responses for compliance. If the higher-cost options are assumed to occur in the baseline, then the cost of generating incremental environmental

[35] Our focus here is not on regulation whose primary purpose is redistributive.

improvement will seem low. If the low-cost options are assumed to be in the baseline, because emitters are supposed to seek them out to meet existing environmental requirements, a different picture will emerge.

4.B.4 How Should the Analysis Address Risk and Uncertainty?

Uncertainty and risk are ubiquitous. CBA seeks to identify outcomes with maximal net benefits. (Distributional issues are discussed below.) To implement this evaluation measure under uncertainty, it is necessary for the economic analyst to get as much information as is reasonably possible about the probability distributions underlying important components of benefit and cost, e.g., reductions in health threats, improvements in resource productivity, costs of compliance, and potential for innovation. Of particular importance is information about central tendencies (mean or median) of benefits and costs for the population as a whole, so that aggregate expected net benefits can be evaluated. Information about the variability of possible outcomes also is relevant for judging the "certainty equivalents"--the adjusted net benefits after taking into account the burden of risk-bearing on risk-averse parties. If the scientific assessment of risk provides only information on upper bounds of hazards, the analysis will either overstate the net benefits to the general population or have relevance only to the tail of the distribution whose experience is represented by such outcomes. A similar point applies to worst-case characterizations of compliance cost.

Scientific and economic information about risks and uncertainties often provides little insight into the nature of the probability distribution, and even under more favorable circumstances the distribution might be measured with considerable error. These points underscore the need for considering the sensitivity of the assessment to changes in key assumptions, including the properties of risks and the estimates of costs. Risk assessments and evaluations also need to be updated as the state of science (e.g., the assessment of health risks associated with different air pollutants) grows. Information about the variance of benefits and costs also is important, both to indicate the level of analytical uncertainty and because people can be presumed to be concerned about uncertainty themselves.[36] The Monte Carlo analysis described in Section 3.C is an example of an appropriate treatment of uncertainty.

Aside from information about the probability distribution of aggregate costs and benefits, E.O. 12866 puts additional emphasis on "distributional"--i.e., equity--issues, including effects on especially sensitive subpopulations or other groups (such as the historically disadvantaged). Subgroup benefit estimates might be more scant or uncertain than estimates for the overall population. Nevertheless, the analyst should seek to provide information about any

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[36] The calculation of "risk premia" is not that common in regulatory analysis. This may be because of unfamiliarity with the concepts, or uncertainty about the appropriate degree of risk aversion to postulate. In other cases, reduction (increase) in variability may not be the primary benefit (cost) of a regulation. A further complication is that population sample variances reflect both population sampling variability and the variability of outcomes for any member of the population. Further research on these issues would be useful.

important distributional effects. Explicit consideration of these effects is preferred to assumed conservatism in the risk assessment to protect the most sensitive individuals.

4.B.5 What Costs and Benefits Should Be Considered?

The economics paradigm seeks the widest practicable range of benefits and costs for inclusion. In all cases, however, it is necessary to ensure that the costs included are truly opportunity costs rather than just transfer payments. That poses analytic challenges when there are market distortions (the exercise of market power or distorting tax and subsidy provisions). Similarly, the focus in benefits assessment should in principle be on aspects for which there is WTP. Where willingness to pay is highly uncertain (e.g., in assessing the social value of some ecosystem services), other information needs to be provided.

A particularly nettlesome issue in CBA is the treatment of impacts on employment and local economic activity. Many analyses of regulations have purported to calculate how many jobs a regulation "creates." Closer scrutiny of those studies reveals that they often treat the supply of labor services as unlimited, so increases in employment as a consequence of a regulation have no opportunity cost in terms of diversion of productive activity from other parts of the economy. Economists generally view the job-creating potential of regulation with considerable skepticism, although a regulation can increase the use of unemployed or underemployed workers. In the absence of evidence that such conditions prevail, employment effects should be noted but not counted as net benefits of regulation.

A related issue is the potential effect of regulation on technical innovation, including that embodied in increased worker productivity. Generally, analyses of the future consequences of regulation should attempt to account for potential changes in technology and productivity. Such changes could include regulation-caused innovation, slowing of technical progress, and deflection of technical progress into regulatory response in other parts of the economy. Given the uncertainties surrounding technical change, assumptions about alternative scenarios and their likelihood need to be clearly specified.

4.B.6 How Should Key Market Failures (or Nonmarket Goods) Be Assessed?

Various assessment methods and their limitations were reviewed in Section 3. Different methods will be more or less applicable under different circumstances. A key general point in the OMB guidelines is the need for the use of methods that reflect the current state of the art and for consistency in the use of analytic tools (or more presumptive "rule of thumb" valuations). For analytic tools undergoing considerable continuing refinement, such as stated-preference methods for valuation, that imposes a burden on agencies to maintain consistency with the state of the art. In other cases, consistency is needed in the valuation method itself, such as the valuation measures for assessing the benefits of reduced mortality risk.

In some cases, economic measures will be limited or even nonexistent for some important effects of regulation. Given the breadth of the decision criteria in E.O. 12866, a complete assessment should include a description (and quantification in noneconomic units to

the extent possible) of such effects. Information on the incidence of benefits and costs should also be provided, to the extent possible.

4.B.7 How Should Benefits and Costs Be Compared Over Time?

The economic approach to this issue is discounting, in which future benefits and costs are deflated to reflect the basic idea that people are impatient and prefer benefits sooner rather than later (and mind later costs less than current costs). Modern economic theory points to a preferred approach, the shadow-price-of-capital model (Lind, 1990). This approach can be used to assess how either government outlays or mandated private expenditures displace private consumption or investment and, for the investment that is displaced, to assess the ultimate cost to the economy in reduced future consumption possibilities. With all regulatory impacts converted to consumption equivalents, analysts can discount streams of benefits and costs at a rate that reflects intertemporal consumption tradeoffs. The appropriate rate for such tradeoffs in the United States is generally taken to be around a 3% real, riskless rate.[37] That rate is lower than the "official" OMB rate for the opportunity cost of capital, currently set at 7%. Note that the rates measure different things (the opportunity cost of capital and the consumer rate of time preference generally will differ, given taxation of corporate income and potential limitations on risk markets, including the difficulties in hedging inflation risks).

Whatever the theoretical appeal of the shadow-price-of-capital approach, it must be admitted that there is little practical experience with it and that it can be very sensitive to the choice of means for calculating displaced consumption associated with reduced investment. The OMB rate reflects the overall average return to capital in the economy (including a risk premium for undiversifiable risk). That rate is easier to apply than the shadow-price-of-capital approach and might be a reasonable approximation if regulations primarily affect domestic investment rates.[38] This discussion illustrates the need for sensitivity analysis to gauge how benefits and costs change with alternative discount-rate hypotheses and for careful assessment of the extent to which the burdens of regulation fall on consumption or investment.[39]

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[37] Riskless rates are the rates to use if streams of uncertain benefits and costs have been adjusted for the cost of risk-bearing to risk-averse individuals (so-called certainty-equivalents). This is another example of an issue where theory and practice may clash in the establishment of guidance, since agencies generally have limited experience in such calculations.

[38] Lind's (1990) counterargument to this view is that to the extent the U.S. has global access to capital, domestic capital constraints lose at least part of their force and the relevant discount rate remains the one at which a (domestic or foreign) saver will trade off current against future consumption. On the other hand, a large number of Americans maintain substantial credit card balances at real interest rates well into the double digits.

[39] A special but important issue arises here when regulatory impacts have an intergenerational time scale (e.g., costs borne today but benefits received by the next generation). Even a consumption-based discount rate could reduce future impacts to trivial levels over a long time frame. In terms of discount rate policy, it could be argued that intergenerational effects deserve "special" treatment reflecting societal tradeoffs across generational income distributions. One simple example is the argument that a discount rate reflecting the long-term rate of

4.B.8 How Should Agencies Gauge the Appropriate Level of Effort for Assessing the Economic Effects of Regulation?

In general, E.O. 12866 calls for a level of analysis broadly commensurate with the potential value of information. Requirements for full assessments apply only to "significant" regulatory actions, in particular those expected by the principal decision-makers to have impacts on the economy in excess of $100 million per year. Within that limit, it is still possible to scale the depth of analysis to the need for it. When benefits are compelling and costs seem limited, less analysis might be warranted than when the reverse is true. Even when the stakes of good decision-making are high, gross uncertainties can limit the scope of useful analysis (a fact that should also affect decisions). Statutory limits also constrain the set of regulatory options (although some analysis of the opportunity costs of these constraints would be valuable, as the OMB guidelines note).

In striking the necessary balance, regulatory guidance has tended to emphasize the establishment of general concepts and principles, rather than specific quantitative rules. For example, there has not been consistent numerical guidance for the valuation of mortality-risk reduction. But the establishment of clearer numerical guidelines runs the risk of overprescribing valuations that are not comparable with a situation under consideration (e.g., the valuation of avoiding cancer death risk through a measure that reflects WTP for lower risk of an occupational-accident death). Ultimately, the process works only if there is a commitment from agency heads on down to follow the principles and to justify principal valuation assumptions, including their consistency with existing empirical information; an equally strong commitment on the part of all concerned to follow good scientific principles in issue framing, analysis, and review; and OMB is able to enforce quality control.

4.B.9 Interpretation of Statutory Requirements

Agencies often interpret basic statutory requirements for protecting the environment, health, and safety very differently. They also interpret constraints on the use of economic information in setting regulatory requirements differently. That is at least partly due to the vagueness of statutory language, differences in interpretation of judicial decisions, and differences in regulatory philosophy. One consequence is substantial differences in the thoroughness and quality of regulatory assessments.

Although basic uncertainties and disagreements about statutory requirements must be addressed at the policy level or through judicial actions, differences in agency philosophy or interpretations regarding the importance of CBA can and should be addressed as part of the implementation of the regulatory review called for under E.O. 12866. The new OMB

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economic growth can reflect an "equal" treatment of the generations, reflecting the presumed greater economic ability of future generations to shoulder burdens relative to ourselves. An alternative perspective is that intergenerational resource allocations are not discounting issues at all; rather, they reflect the value placed by the present generation or conveying collective benefits to their descendants. Much more research is needed to clarify these issues, especially at an empirical level.

guidelines lay out a set of requirements that, although flexible enough to be tailored to individual circumstances, provide a norm against which all assessments can be judged. Moreover, even where statutory language limits the scope of use of CBA information in rulemaking (explicitly or through judicial interpretations), some assessment adequate to indicate the benefits and costs should accompany any proposed significant regulatory action. That information is important for informing legislators, policy-makers, and the general public about the consequences of regulation, for building support for regulation that serves the public interest, and for highlighting opportunities for legislative or regulatory improvements. These issues are closely linked to the broader question of what information has standing in the regulatory process, which we discuss in Section 5.

4.B.10 Damage versus Benefit

A reasonable conjecture is that people would be willing to pay more to avoid worsening conditions than to obtain improved conditions. To the extent that that is true, reliance on a damage estimate when a benefit estimate is called for leads to an overestimate of WTP and *vice versa*. It is important to use the appropriate type of estimate.

The distinction between damage and benefits does not affect only the valuation step. The presence of thresholds or important, continuous nonlinearities in dose-response functions could also lead to errors in transferring a benefit study to a damage context. Damage to lakes as a result of acid rain is a good example. Lakes have thresholds beyond which input of acid surpasses the buffering capacity. Estimating damage from an increment of acidity in a group of lakes, of which some have passed this threshold, some are close to it, and some have much buffering capacity left is difficult in the best of circumstances. But reversing a sign on the results of a study of the benefits of reducing acid deposition to the same group of lakes could not possibly provide a reasonable damage estimate.

4.B.11 Marginal versus Average Damages

The appropriate estimate of damage is one taken at the margin. In the context of the debate over "adders" to value spillovers from electricity generation, for example (see Lee et al., 1995), that means the value of impacts with respect to an addition to existing generation capacity. The literature of damages and benefits rarely is cast in marginal terms; rather, one usually sees estimates of the total damage from a pollutant divided by the number of tons of that pollutant emitted to obtain an estimate of damages per ton of pollutant. Where all components of the impact pathway are linearly related (i.e., from emissions to valuation), marginal damage and average damage are equal, and this approach is acceptable. But this condition is exceedingly stringent, inasmuch as few pollutant dispersion models are linear and many dose-response functions and some valuation functions in the literature are nonlinear.

4.B.12 Issues in Cost-Effectiveness Analysis

As noted previously, CEA is a special case of CBA in which the primary regulatory goals are fixed and the analysis attempts to highlight the least-cost means of achieving them. All the general arguments in this section about good CBA practice apply as appropriate to CEA. It is also especially important in CEA to ensure that the measures of costs of policy alternatives are truly comparable. Aside from ensuring that cost definitions are consistent across alternatives (i.e., full opportunity cost is evaluated for all options), it is important in comparing options to take into account that in practice they might not all achieve precisely the same outcomes; Policy A might inherently provide a joint benefit relative to Policy B, for example. Ensuring full comparability in this case requires a measure of CBA to adjust for differences in benefits. That can be done, for example, by deducting the value of ancillary benefits from the cost of Policy A in the example above.

4.B.13 Application of General-Equilibrium Methods

We argued in Section 3 that in some cases, consideration of general equilibrium effects of policy is crucial in developing reliable calculations of their full benefits and costs. CGE models are still evolving; they can be expensive to develop and maintain, and there is debate about how they should be structured. Nevertheless, agencies should make efforts to understand general equilibrium issues better by investing in the further development of CGE tools and analyses of their outputs.

5. OVERARCHING ISSUES

The improvements in methods for estimating the costs and benefits of regulatory activities discussed above are necessary but insufficient for substantially improving regulatory decisions. In addition, some overarching issues involving the role of CBA in public decision-making must be resolved. Some of these issues are motivated by the debates over regulatory reform in Congress, others by debates in the executive branch. This section examines eight such issues and offers some suggestions for at least their partial resolution.

Some issues prominent in the regulatory reform debates are absent from this list because their resolution goes beyond the debate over the methodology of CBA and its role in regulatory decision-making into the broader political arena of legislative and executive decision-making. These issues include, notably, supermandates that would overturn existing statutory criteria for decisions retrospectivity (subjecting previous regulatory actions to a cost-benefit test), and a change in the standard of judicial review (the provision to make regulatory impact analyses and supporting studies objects of suit, rather than subjecting regulatory actions just to an "arbitrary and capricious" test).

5.A Decision Rules

What role should CBA play in an agency's decision regarding a potential regulatory action? Currently, CBA is variously required, endorsed, circumscribed, or eliminated by statute. Agencies subject to OMB guidelines must use CBA unless a statute (or a court)

requires otherwise, but there is considerable discretion in the guidelines as to how it is used. Therefore, the nature and extent of the use of CBA vary not only because of statutory provisions but for a host of reasons related to agency history, the training and interests of agency executives and staff, interpretations of statutory requirements, deadlines and resource constraints, and the like.

There are three general options for using CBA, ranging from the most formal and binding to no role. One could develop many variants of these options.

1. Strict cost-benefit test. Social benefits and costs of a regulatory action would be estimated and net benefits computed. Positive net benefits would be a necessary condition to proceed with the regulatory decision-making process and the consideration of other decision criteria.[40] Assuming that all or most benefits and costs of a potential rule can be quantified, option 1 implies that a rule must maximize aggregate net benefits to society to go forward. The language in early versions of S.343, that benefits must be shown to "outweigh" costs, best reflects this option.

2. Cost-benefit test as one of several factors in decisions, which are not based solely on a simple benefit-cost test. Net benefits would be estimated and constitute one of several criteria in the regulatory decision. A rule with negative measured net benefits could still be promulgated if other factors (such as an improvement in the equity of the income distribution) could be shown to justify the action. A discussion providing the justification would be required. This approach would be broadly similar to the approach to implementing the "justify" criterion in E.O. 12866. However, agencies would be required to quantify benefits and costs as much as is reasonably possible, and they would have to give this information standing comparable with that of other factors in the assessment (Section 5.B addresses this standing issue in more detail).

3. No role for benefits and costs. There are many examples of agencies' ignoring benefits but considering costs and vice versa. Under current statutes, such as the Clean Air Act's Title I, agencies are not permitted to consider costs in setting ambient-air quality standards, whereas the act is silent about benefits. OSHA historically considers the costs of its regulations, but not their benefits (e.g., the monetary value of risk reductions).

Option 1 would be preferred by many economists in principle if benefits and costs could be estimated with little uncertainty. Opposition to this option stems partly from the fear

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[40] Obviously, one could offer, as an extreme form of option 1, an option where the only criterion for decisionmaking would be positive net benefits.

that a showing of negative quantified net benefits would doom a regulation, irrespective of its other positive qualities. Option 1 also implies that the efficiency criterion occupies a position of primacy in public decision-making. We find this position difficult to defend, particularly once one admits of uncertainty and the inability to qualify some types of benefits and costs. With Option 2, in contrast, efficiency is recognized as an essential element of the decision but not necessarily superior to other elements. However, it is important in implementing Option 2 that assessments of benefits and costs reflect sound economic practice and that this information have standing comparable with other factors in decision-makers' portrayal of benefits and costs of potential rules. Finally, Option 3 implies that inefficiency in rulemaking has no standing. We reject this option without qualification and submit that agency decisions regarding rules that are likely to have a major effect on the economy already implicitly account for costs and some notion of what will be gained, however vague, irrespective of statutory mandates; such accounting should be more systematic and transparent.

5.B What Has Standing in a CBA?

5.B.1 Nonquantifiable Elements

The choice of decision rules is intimately tied to the issue of what types of effects have standing in a CBA. The most direct tie, and one alluded to in Section 5.A., is through the standing of different elements of benefits or costs. Other than the issue of aggregation of different types of benefits, it is a basic principle of CBA that all benefit types should have standing, whether they are quantifiable or not. As shown in Section 3, those who devote part of their professional lives to the estimation of environmental benefits would be the first to admit that some types of benefits (and costs!) are extremely difficult to quantify or, with current scientific understanding and economic tools, not yet possible to quantify. Ignoring them on such grounds is unacceptable.

Rather, the key issue is how to treat nonquantifiable elements. There are several options. One that has found favor among economists is a value-of-information approach. This involves estimating the net benefits for the quantifiable elements and asking how large the nonquantifiable elements would have to be to reverse the conclusion of the analysis. If the nonquantifiables elements were all on the benefits side and the net benefits were positive, information on the nonquantifiable benefits would have no value for the decision. If the net benefits were negative, the nonquantifiable elements would have to be at least as large to reverse the outcome of the analysis. The analyst or decision-maker could then make a judgment about whether the nonquantifiables elements were likely to be greater than this amount--an easier judgment than one about the possible size of the nonquantifiable benefits.

A broader approach in the same vein would be to ask how large the nonquantifiable elements would have to be to alter the *regulatory decision* (as opposed to the outcome of the CBA) that would be informed by the quantifiable elements of the analysis. This type of approach could be performed in either a quantitative way or as a matter for a decision-maker's judgment.

Note, however, that these approaches become unwieldy if both costs and benefits have unquantifiable elements. In such a case, as in all other cases, the nonquantifiable elements should be described as precisely as possible to provide the best information to the agency decision-maker and reviewers.

Finally, care should be taken to ensure that nonquantifiable elements are not automatically given less weight than quantified elements, but the state of the science in various areas should be provided to inform the decision-maker's judgment. There should be a recognition that the reason some elements have not been quantified is that researchers and funders have accorded other areas of study a higher priority. The former areas might be given a low weight, *a priori*. Other areas might have received much attention in the research community but so far defied quantification, although ample qualitative information exists to be concerned. *A priori*, these areas might be accorded a large weight. And still other areas might simply have been overlooked, in which case no prior judgment can be formed about their likely impact.

For instance, with respect to health benefits, the effect of air pollutants on the incidence of chronic illness has been intensely studied but has not yet yielded credible quantitative relationships. One can presume that this element could be quite large. But the effect of conventional air pollutants on birth disorders has received very little attention, and one may presume that it is unlikely to be large. Finally, the effect of some toxic chemicals on birth disorders has recently come under much scrutiny, but their importance remains very unclear.

5.B.2 Quantifiable Elements

If nonquantifiable elements should have standing, as noted above, it is equally important that quantifiable elements have standing. That might seem obvious, but some statutes proscribe the setting of regulatory requirements on the basis of a balancing of benefits and costs. Moreover, some court decisions have held that CBAs cannot be considered by agencies unless specifically authorized by statute (see Warren 1996). Even if one accepts that that is a considered judgment of the American people (which we do not), it is nonetheless important that information about benefits and costs be available so that such a judgment can be re-evaluated periodically on the basis of the results that it engenders. In that light, court decisions that would prevent agencies from even carrying out CBAs unless specifically called for in a statute) are even more troubling. We strongly believe that such proscriptions of the gathering of information are contrary to good government and should be overturned.

To implement our second option in Section 5.A, statutory proscriptions and judicial limitations on *considering* benefits and costs in rulemaking would also have to be overturned. Note that such a change does *not* inherently require that agency decisions reflect a narrow cost-benefit test (the first option). It requires only that quantifiable benefit and cost information have standing and be used by decision-makers to make regulatory determinations that are not arbitrary and capricious and are based on the full record.

5.C Uncertainty and Decision Rules

There is often a significant degree of uncertainty about both costs and benefits when environmental regulation is at issue. Fundamental change in the treatment and reporting of this uncertainty could do much to improve the regulatory process and lead to better decisions. The main idea is to appropriately describe the uncertainties and to separate the description of the uncertainties in the CBA from the decision-makers' judgments about the degree of risk aversion to unfavorable outcomes (or the willingness to take risks to obtain more favorable outcomes) appropriate to a given public policy decision. The uncertainties should be described quantitatively to the extent possible, but some descriptions of uncertainty should always accompany central tendency estimates.

On the quantitative side, as described previously, Monte Carlo simulation approaches or other techniques can be used to define a probability distribution of the net benefits of a rule. Such a distribution would provide a probability for each of a range of outcomes in response to a given regulatory initiative. The distribution would often have negative benefits over some range of probabilities and positive benefits over another range. The decision-maker might feel that, say, the small chance of a negative outcome is outweighed by the large chance of a positive one or that the precedential value of going ahead with a given regulation, as well as the signal it sends to the regulated community that EPA means business, is worth the chance (even if it is large) of a negative outcome. In our view, such a rationale is legitimate, so long as the logic underlying it is made clear.

5.D Justification, Transparency, and Peer Review

That last point brings us to the overarching issue of how an agency ensures the credibility of its analyses and the rationale for its rules. The answer is uncomplicated in theory. Agencies need to be clear about their justification for proceeding with a regulatory action, especially when the regulation fails an implicit or explicit cost-benefit test. They should have the scientific and economic assessments underlying major rules peer-reviewed, and both analysis and peer review should be done early enough to influence the outcome of the analysis, not to rubber-stamp decisions made on other grounds.

For example, EPA uses the Science Advisory Board and the Clean Air Science Advisory Committee in a peer review function for particularly controversial or major studies (such as the impact assessment for RCRA rules, which involved a contingent-valuation study eliciting nonuse values of limiting groundwater contamination). Such reviews are helpful, but they are not widespread and, with many other items on the agendas of such boards, cannot become so without expanding the board membership considerably. At the same time, EPA has dismantled its internal review process, historically conducted by the Office of Policy, Planning, and Evaluation. That leaves the only independent institutionalized review with OMB under Executive Order 12866. This review, which accompanies the proposed regulations, is near the end of the regulatory process and therefore has less of an influence on the quality of the analysis and its use in shaping regulations than is desirable.

That is not to say that program offices are not capable of producing good analyses. An excellent example of clarity and even courage in the justification of a government position is the U.S. EPA Water Office's report on the costs and benefits of the administration's version of a reauthorized Clean Water Act (1994). The executive summary admits that the measurable costs exceed the measurable benefits of the proposed changes in the act by a wide margin (and states that for other reasons, including the large number of nonquantifiable benefits, the administration believed that it was worthwhile to proceed). The body of the report clearly shows how this conclusion was developed and presents the uncertainties in these estimates.

One idea for improving the quality of agency assessments beyond what OMB can accomplish with its limited resources is to institute a governmentwide peer review of selected agency assessments (e.g., those with effects over $100 million per year, the threshold in E.O. 12866). That could be accomplished through an interagency process broadly patterned after the reviews led by the Council on Wage and Price Stability (the institutional predecessor of OMB's Office of Information and Regulatory Affairs) and the Council of Economic Advisers in the 1970s. Alternatively, the reviews could be carried out by nongovernment contractors with the necessary skills and objectivity. Early reviews could have a useful effect on the content of a proposed rule, while a draft rule is being developed. Alternatively, if agency sensitivities or legal and other considerations preclude that, a systematic review of analyses supporting major proposed rules that have been issued for public comment still would provide useful information and a longer-term record for judging the quality of agency assessments.

Other issues need to be addressed in considering this strategy, not the least of which is the role of OMB. Nevertheless, we believe that some kind of systematic governmentwide peer review could improve the quality of agency assessments and provide agency managers with additional incentives to seek such assessments in a time of limited budgets, competing priorities, and political conflicts. A similar review function associated with the newly instituted 60-day Congressional review period for major regulations could also play a salutatory role.

5.E Treatment of Specific Regulatory Effects

The recent debate over regulatory reform highlights several benefit and cost categories that present special concerns in a CBA. Chief among these are nonuse (or passive-use) values and effects on employment and international competitiveness.

5.E.1 Nonuse Values

Some versions of the regulatory reform bills have contained provisions excluding a class of values from the benefit estimates--nonuse or passive-use values. Such values are the amounts that people would be willing to pay for improvements in environmental-resource quality that are unrelated to amounts that they would pay for their use of the resource.

Research on nonuse values makes it clear that people are willing to pay something to protect some resources that they have never used and do not intend ever to use, whether it is the bay in Alaska despoiled by the Exxon Valdez or the Serengeti Plain. Such values clearly

should have standing in CBAs for policies affecting natural-resource qualities and quantities. Where such standing has been questioned, such as in the Congressional debate over regulatory reform, the deeper objections are partly about the reliability of techniques designed to capture such values, and partly about who should be liable for damages to these values. Furthermore, if nonuse values are to be denied standing in benefit estimation, they should also be denied standing in cost estimates. In this case, the values people are willing to pay to preserve logging jobs in spotted owl protection areas and to preserve the way of life of ranchers who depend on grazing rights would also be ignored.

5.E.2 Unemployment and Competitiveness

As noted previously, CBA and the economic paradigm that underlies it do not allot a role, per se, for considering the employment effects of a government action. In the calculation of the social costs of such action, the costs to the economy associated with the reallocation or "loss" of resources--such as labor, materials, and capital that might be a consequence of the regulation (if, say, a company cut back its production or went out of business)--are, in theory, captured by the analysis. In a reasonably well-functioning economy, many of these displaced resources are re-employed after some transition period; hence, job loss might occur for only a short time. It is appropriate to track such losses and value them at their contribution to the economy--what economists term their marginal product (perhaps also subtracting an amount to represent the benefits of leisure time). Some have argued for also adding personal and family costs of unemployment to such estimates--on the basis of increased alcoholism, domestic violence, and suicide rates among the structurally unemployed; this is not yet standard practice.

Similarly to unemployment, the effect of regulation on the competitiveness of firms in particular sectors or of U.S. industry relative to the world economy do not figure directly in a CBA. There is not even a consistent relationship between an increase in competitiveness and a country's social welfare. Because U.S. trade competitors in the supply of goods are also major demanders of our goods (and we of theirs), improvements in their "competitiveness" (in the sense of selling more), to the extent that it improves their prosperity, increases demand for our goods. Our growth is not at the expense of a competing country's growth. Both countries can be made better off because they trade with one another. In Paul Krugman's (1994) terms, "international trade in not a zero-sum game" (p.34).

5.F Integrated Assessment

The regulatory-reform debate has focused on improving CBA and risk assessment without a clear understanding of the overlap between the two. In contrast, we argued in Section 4 of this paper that risk assessment is an input into a CBA and offered a number of suggestions on how risk assessment can be modified to be more useful in CBA.

But the issue of the overlap and coordination of different disciplines to improve the quality of CBA is not limited to risk analysis and economics. Rather, one can think of CBA as an integrated assessment, involving the coordination of multiple disciplines. For air-quality regulations, for instance, a credible CBA will involve the results of a team effort involving

experts in the abatement of pollution and its cost and resulting emissions; air-quality modelers; experts in the response of human health, crops, materials, and other sensitive "receptors" to pollution; risk assessors; and economists. Disciplinary jargon, differences in paradigms and unstated assumptions, and different expectations for the output of analysis all conspire to make such teamwork challenging. However, transparency and credibility demand that the challenge be met.

5.G Use of CBA in Legislative Design

Although much of the focus in debates over regulatory reform and CBA has concerned the role of CBA in assessing proposed regulations (or revisiting existing regulations), CBA also could play a constructive role in assessing the design of new legislation. A key challenge in such an application would be to identify the specific requirements that would flow from new legislative language. Often, new legislation only states general goals, and substantial rulemaking and litigation are required to determine a workable legal interpretation of the legislative charges. Application of CBA while legislation is being crafted could be useful not just in showing the potential consequences of a legislative requirement, but also in forcing more careful consideration of what statutory language would actually require (including unintended consequences). The recent effort by the EPA Water Office to estimate the costs and benefits of proposed changes to the Clean Water Act (cited above), as well as later changes in agency positions, is an example of the constructive role that CBA can play in the legislative arena.

5.H Interagency Consistency in Methods

Along with consistency in the treatment of risk and uncertainty, one of the greatest opportunities for enhancing the caliber of CBA is to enforce greater consistency in CBAs across agencies. We see two major areas for consistent treatment. The first is in the reporting of CBAs and the rationale for agency decisions. The second is in the methods used to value estimated benefits and costs. We do not endorse the idea that all agencies should be required to use the same *values* in their CBAs. We do support interagency consistency in the *logic and procedures* by which these values are inferred.

5.H.1 Reporting

It would be useful to reviewers, Congress, and stakeholders if regulatory assessments were issued in the same basic format with explicit discussion of key decisions associated with analytic components defined a priori. Examples could include the elements in Section 4, such as treatment of the baseline, uncertainty, and discounting. The agencies might find a required format constraining, of course, but useful as well, because it would help to ensure that all key steps in the analysis were explicit and head off difficulties in the review process.

5.H.2 Methods

One example will illustrate the idea that agencies should be more consistent in their estimation of costs and benefits. A succession of administrations has refused to establish an

explicit value (or range of values) for a mortality risk reduction. Neither has an administration established a benchmark value of "point of departure" to use in evaluating a "cost-per-statistical-life-saved" estimate of a regulatory option. As a result, under current guidance, agencies may choose not to value mortality risks explicitly and not to subject their regulations to a comparison with a cost-effectiveness benchmark.

This inconsistency takes several forms, including whether an analysis even includes explicit values for mortality risk reductions, how such values are incorporated, and what values are chosen. For agencies that explicitly value mortality risk reductions, the implied "value of a statistical life" ranges from $1 to $10 million. Although EPA's regulatory-impact analyses (RIAs) occasionally value statistical lives saved, each office uses different values. DOT requires that all its agencies compare their cost-per-life-saved estimates to a single benchmark of around $2.8 million. OSHA has a policy of not considering values of lives saved either explicitly or with reference to a benchmark in its assessments.

When agencies do not explicitly value death-risk reductions but instead make decisions based on an "acceptable" "cost-per-life saved," the implicit value of a statistical life can be far higher. One study of EPA regulatory decisions affecting cancer risks found regulations promulgated that cost over $50 million per "life saved." OMB's own study of such behavior involving a broader range of causes of death found even higher costs per life saved, as did a recent CBO study of drinking-water standards.

The problem can be reduced by encouraging agencies and departments to value mortality risks with "best estimates" of such values. These estimates can be devised in an interagency process that takes into account the range of uncertainty around such values in the literature, including the comparability of various types of risks, as discussed in Section 3 above. Government and private resources are less likely to be wasted when rules issued by one agency more consistently reduce mortality risks at comparable costs. Explicit valuation of reductions in mortality risks also makes it easier to compare regulatory alternatives where there are nonquantifiable benefits.

At the same time, it is important to permit agencies some flexibility in their adoption of values for key effects, such as mortality risk reductions. Recent research on the ranking of risks and the WTP to avoid different types of risks suggests that such values are influenced by the characteristics of the risk (e.g., dread, scale), its context (controllability and voluntariness), the age at which the risk is borne, and the latency of the risk. It is not clear that the WTP for risk reduction to avoid accidental death is equal to that for avoiding death in an environmental context. Thus, although such agencies as DOT and EPA should think about the problem of valuing mortality risks in a similar way, they should not necessarily use the same values.

6. CONCLUDING REMARKS

The efforts in the 104th Congress to legislate requirements for cost-benefit analysis and the revised OMB guidelines for the conduct of such assessments of regulations highlight the

need for a comprehensive examination of the role that CBA can play in agency decision-making. This white paper summarizes the state of knowledge and offers suggestions for improvement in the conduct and use of CBA, especially in the context of environmental regulations. Its scope is not confined to assessments of cancer risks or other issues of concern with toxic substances, but includes the entire range of environmental policy issues.

CBA is a technique intended to improve the quality of public-policy decisions by using as a metric a monetary measure of the aggregate change in individual well-being resulting from a policy decision. Individual welfare is assumed to depend on the satisfaction of individual preferences, and monetary measures of welfare changes are derived by observing how much individuals are willing to pay--i.e., willing to give up--in terms of other consumption opportunities. This approach can be applied to nonmarket "public goods" like environmental quality or environmental-risk reduction, as well as to market goods and services, although the measurement of nonmarket values is more challenging. Cost-effectiveness analysis is a subset of CBA in which a policy outcome (e.g., a specified reduction of ambient pollution concentration) is taken as given and the analysis seeks to identify the least-cost means for achieving the goal (taking into account any ancillary benefits of alternative actions).

To its adherents, the advantages of CBA (and CEA) include transparency and the resulting potential for engendering accountability; the provision of a framework for consistent data collection and identification of gaps and uncertainty in knowledge; and, with the use of a money metric, the ability to aggregate dissimilar effects--such as those on health, visibility, and crops--into one measure of net benefits. Criticisms of CBA hinge on questions about (a) the assumption that individual well-being can be characterized in terms of preference satisfaction, (b) the assumption that aggregate social well-being can be expressed as an aggregation (usually just a simple summation) of individual social welfare, and (c) the empirical problems encountered in quantifying economic value and aggregating measures of individual welfare.

We take (a) as axiomatic, noting also that because CEA is a subset of CBA, philosophical objections to the use of a preference-based approach to individual welfare measurement apply equally to both. For (b), we agree that CBA does not incorporate all factors that can and should influence judgments on the social worth of a policy and that individual preference satisfaction is not the only factor. Nevertheless, we assert that CBA must be included as a key factor. Other arguments under (c) are measurement problems related to how choices based on preferences permit one to infer economic values in practice.

The state of the science of measuring such economic values is exceedingly active. Estimates of the WTP for reductions in mortality and morbidity risks, for avoiding environmental damages to recreation opportunities, and for avoiding visibility degradation are the most active and successful areas of valuation. Controversies of a higher order stalk the estimation of nonuse values, and a variety of mostly empirical concerns have left material damages poorly understood. Estimation of the costs of reducing environmental effects, generally thought to be relatively straightforward, are at least as challenging as estimating the

benefits, although there are easy-to-estimate, but perhaps poor, proxies for the loss in social well-being that such costs represent.

This paper has offered a number of suggestions to regulatory agencies in conducting CBA, drawing on the "best practices" identified in the recently issued OMB guidelines. These include the use of clear and consistent baseline assumptions; the evaluation of an appropriately broad range of policy alternatives, including alternatives to new regulation; appropriate treatment of discounting future benefits and costs and accounting for the cost of risk-bearing; the use of probabilistic analyses and other methods to explore the robustness of conclusions; the identification of nonmonetizable or nonquantifiable aspects of a policy and the potential incidence of all effects; and the use of benefit and cost measures that are grounded in economic theory (i.e., measures of WTP and opportunity cost).

The paper also argues that from an economic perspective, risk assessment is a subset of benefit analysis in that quantitative relationships between pollution exposure and some human or ecological response are needed to estimate the effects and thus the marginal change in welfare resulting from a policy. That the culture of risk assessment is not generally oriented toward this role implies that risk assessments do not always provide the necessary input to an economic benefit analysis. Suggested changes in risk-assessment practices include estimating population risks, not just individual risks; providing information on the entire distribution of risks, including central tendencies, rather than just upper-end risk measures based on conservative assumptions about the potential threat; providing as much information as is practicable about how risks vary with exposure, rather than just identifying "safe" or "acceptable" threshold levels of exposure; and considering substitution risks as of equal importance as direct risk reductions. Economists and risk assessors together must also address how to give appropriate attention to both lay perceptions and expert assessments of risks.

Improvements in the methods for estimating the costs and benefits of regulatory activities are necessary but not sufficient for substantially improving regulatory decisions. Several more overarching issues involving the role of CBA in public decision-making must also be debated and resolved. These include the following:

- *Decision rules and CBA.* Although decisions should not be based solely on a simple cost-benefit test, a CBA should be one of the important factors in the decision. This approach is entirely consistent with Executive Order 12866. A rule with negative measured net benefits could still be promulgated under this approach if it could be shown that other factors (such as an improvement in the equity of income distribution or an enhancement of environmental justice) justified the action. A discussion providing the justification would help to ensure accountability.

- *Quantifiable benefits and costs.* CBA needs to have standing as a part of all major regulatory *and legislative* decisions. In particular, it must have standing to implement the decision approach outlined above. Administrative reforms could accomplish much, but

legislative changes will be needed to implement this suggestion where the use of CBA is now precluded.

- *Nonquantifiable elements and CBA.* A value-of-information approach should be used. This involves estimating the net benefits for the quantifiable elements and asking how large the nonquantifiable elements would have to be to reverse the conclusion of the analysis or, as a broader measure, the regulatory decision. This provides information about nonquantifiable elements (beyond their enumeration and description) in a format useful for the decision-maker.

- *Goals and standards: marrying efficiency and equity.* CBA can be given appropriate standing and be introduced systematically into goal-setting without compromising other social concerns. First, regulatory goals or aspirations should be developed that ideally are expressed as a range of acceptable risk and are based on health or other criteria that reflect equity or fairness concerns. Second, CBA, defined broadly, should be used to justify where the standard would be set within this range or, to the extent that the range expressed aspirations rather than more-concrete requirements, how far toward the stated goal the regulation should go. An example of this approach can be seen in the recent Congressional actions to reauthorize the Safe Drinking Water Act.

- *Ensuring credibility of analysis.* Agencies need to be clear about their justification for proceeding with a regulatory action, especially when the regulation fails an implicit or explicit cost-benefit test. They should have the scientific and economic assessments underlying major rules peer-reviewed, and both the analysis and the peer review should be done early enough to influence the outcome, not to rubber-stamp decisions made on other grounds. Peer review can be inside an agency (although EPA has recently dismantled this function), part of an interagency process, part of an expanded role for OMB, or even privatized. The combination of expanded peer review and timely completion of analysis would also greatly support and enhance the performance and perceived credibility of the existing Executive Branch regulatory review process managed by OMB.

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